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86th Congress
2d Session } COMMITTEE PRINT

SPACE RESEARCH IN THE LIFE SCIENCES: AN INVENTORY OF RELATED PROGRAMS, RESOURCES, AND FACILITIES

REPORT

OF THE

COMMITTEE ON

AERONAUTICAL AND SPACE SCIENCES

UNITED STATES SENATE

JULY 15, 1960

Printed for the use of the Committee on Aeronautical and Space Sciences

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LETTER OF SUBMITTAL

JULY 15, 1960.

Hon. LYNDON B. JOHNSON,
Chairman, Committee on Aeronautical and Space Sciences,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: The accompanying staff report, "Space Research in the Life Sciences: An Inventory of Related Programs, Resources, and Facilities," is forwarded for your consideration and submittal to the Congress.

The purpose of the report, prepared pursuant to your request, is to serve members of the Committee on Aeronautical and Space Sciences and the Congress as a whole as a reference document of factual information about space medicine programs in the Government's extensive space-related life science activities.

The report was prepared by Dr. Earl W. Lindveit and it was reviewed by the other members of the professional staff. The information it contains—current as of date of publication—was supplied by the National Aeronautics and Space Administration, the Department of Defense, and other official sources. No attempt has been made to aditorialize or to present other than factual information.

The need for basic information such as this about the Nation's space program has become increasingly evident in order to provide a more complete understanding of the rapid advances in space technology resulting from continued scientific achievement.

Respectfully yours,

KENNETH E. BELIEU,
Staff Director.

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REPORT

INTRODUCTION

The purpose of this report, made at the request of the chairman, is to serve members of the Committee on Aeronautical and Space Sciences and Members of the Congress as a whole as a source of information about research conducted in the life sciences in support of, or related to, aeronautical and space programs. Such programs—primarily in the fields of medicine, biology, and psychology—are referred to by a number of identical or related terms, including: aviation and space medicine; space biology; bioastronautics; human factors; aerospace medical sciences; aerospace biosciences; and aerospace life sciences.

The report contains factual information on the role and importance of the life sciences in national space activities. While space accomplishments in the physical sciences are popularly recognized and intently followed, less information seems to be generally known about the relationship of the life sciences to space progress—although both scientific areas are of vital importance to the eventual achievement of manned space flight and exploration. Gains in the life sciences promise also to have application in broad benefits to mankind in general.

The most significant life science programs in space-related areas presently being conducted by various Government agencies are included in the report in order to provide a factual basis for evaluating the adequacy of present and proposed efforts to coordinate and utilize such programs. The report thus serves as an inventory of broad information about current life science programs throughout the Department of Defense as well as a description of proposed activities in the newly established Office of Life Science Programs in the National Aeronautics and Space Administration. It includes an accounting of the men, money, and material invested in life science programs in the Department of Defense through descriptions of 32 of the larger programs, involving approximately 2,800 civilian and military professional and supporting personnel, a total overall investment in facilities and equipment of over $61 million, and a research budget for fiscal year 1961 of over $38 million. The NASA Office of Life Science Programs anticipates for fiscal year 1961 a staff of 32 professional and supporting personnel and an estimated total program expenditure of $5 million. In testimony before the House Committee on Science and Astronautics on June 15, 1960, the Director of this Office indicated that within 4 to 5 years the number of professional personnel would total 60, exclusive of additional supporting personnel.

While a complete appraisal of the utilization and coordination of Government life science programs is not an intention or result of this report, it does serve to provide background information in a specific area of space activity.

Space Research in the Life Sciences: An Inventory of Related Programs, Resources, and Facilities

PART I. THE ROLE OF THE LIFE SCIENCES IN THE NATIONAL SPACE PROGRAM

1. Summary and Conclusions

The achievement of future manned space flight no longer appears to be subject to serious question. Solution of the broad variety of problems involved in the attainment of manned space flight requires extensive scientific activity and progress—but the time is approaching when the scale of accomplishments will be in balance with the scale of requirements. Because the achievement of space flight also requires that man survive and function productively, one of the most important areas of space research resides in the life sciences, more frequently referred to by the term "space medicine."

Two categories of factors generally describe the scope of requirements for successful manned space flight of an extended duration. The first category includes: (1) dynamic forces imposed by the vehicle in the process of launching, flight, atmosphere reentry, and landing; (2) the life support system containing components necessary to furnish such basic requirements as food, clothing, water, pressure, oxygen, and protection against toxicants; (3) medical monitoring of human physical functioning and of equipment furnishing vital needs; and (4) food, oxygen, and water regeneration on long-term flights. The second category of factors for crew safety and effectiveness—sometimes referred to as "the great mystery of manned space flight" because they cannot be fully duplicated on Earth—include isolation and confinement, the condition of weightlessness, and cosmic and nuclear radiation hazards. A number of separate problem areas in the life sciences are also included in the general categories of extraterrestrial life, stress factors, radiation, and closed environments.

LIFE SCIENCE PROGRAMS IN THE DEPARTMENT OF DEFENSE AND NASA

In July 1959 NASA Administrator T. Keith Glennan appointed a Bioscience Advisory Committee to assess and prescribe the role of NASA in the life sciences. The report of the NASA Bioscience Advisory Committee—which is reproduced in full in part II of this report—includes the following description of Department of Defense resources in this area:

> * * * Study of the physical, chemical, biological, and psychological stresses of space flight requires an extensive array of apparatus and a large staff of trained scientists and

technicians. Additional facilities and close liaison with the physical scientists and engineers engaged in vehicle research and development are essential to provide proper life-support systems and protection for the passengers in this new form of transportation.

The existing capability for studies of this character is found almost entirely in the military services. Except for a few aircraft companies, civilian agencies have had little need to develop studies of high-altitude, high-speed flight, and NASA itself has so far concentrated almost entirely on the physical and engineering aspects of flight problems.

The military medical services, on the other hand, have been continuously engaged since the First World War in developing facilities and personnel for aeromedical studies. No attempt will be made here to draw up a list of the facilities now available. It is only necessary to note that, taken together, these installations provide a variety and quantity of controlled environment chambers, centrifuges, acceleration tracks, and other relevant apparatus which may not be equaled anywhere else in the world. The committee was especially impressed with the quality of the personnel available for work in these laboratories and their enthusiastic dedication to the job. It is difficult to measure the existing capability in terms of money, but the investment in men and machines must represent at least $80 million and perhaps a good deal more. More important is the time which would be required to build similar installations or train comparable personnel for use elsewhere. * * *

Part III of this report includes descriptions of 32 larger life science programs in space-related areas presently being conducted in the Department of Defense. It indicates that such existing programs involve about 2,800 civilian and military professional and supporting personnel, have a total overall investment in facilities and equipment of over $61 million, and involves a research budget for fiscal year 1961 exceeding $38 million.

The interests and activities of the National Aeronautics and Space Administration in the life sciences extend back to its predecessor organization, the National Advisory Committee for Aeronautics, which began studies of human factors in 1943 in response to the growing complexity of integrating man with the elaborate systems of advanced aircraft. In 1958, one of the first programs of the newly established NASA was Project Mercury, having as its objectives placing a manned space capsule in orbital flight around the Earth, investigating man's performance capabilities and ability to perform in a true space environment, and recovering the capsule and the man safely. Project Mercury was planned and is now being executed as the first in a number of steps toward manned space flight and exploration.

On March 1, 1960, NASA established an Office of Life Science Programs as its fifth major division, based upon a recommendation of its Bioscience Advisory Committee. During fiscal year 1961 NASA anticipates a staff of 32 professional and supporting personnel and a total program expenditure of $5 million. NASA stated that its goals in the

life sciences are: (1) to provide the essentials for survival in manned space flight and exploration, including effective human performance in the space environment; and (2) to achieve greater understanding of the laws of nature as they apply to the life sciences through studies in the space environment. It anticipates a future professional staff of 60, exclusive of supporting personnel.

NEED FOR COORDINATION OF PROGRAMS

The dimensions of the problem of coordination of life science programs can be inferred from the following statement by NASA Deputy Administrator Hugh L. Dryden:

> * * * We are going to continue to use the service laboratories. The estimate is that three-quarters of our effort in this field will always be in the universities and service laboratories. * * *

When a multimillion-dollar program is involved, as will be the case with NASA's life science activities, a sound structure for effective coordination is an absolute requirement. This is expressed as follows in the report of the NASA Bioscience Advisory Committee:

> * * * It is apparent that personnel may be lent from one agency to another, apparatus may be transferred or time made available at military installations with a minimum of administrative difficulty so long as the scale of the operation is kept reasonably small. All those who provided information for the Committee were unanimous on this point.
>
> The situation is far more dubious with respect to large or continued programs involving extensive transfer of personnel, facilities, or funds. Complex contracts of this character would doubtless have to be channeled to rather high levels in the Department of Defense with concomitant delays and uncertainties. * * *

In a speech referred to in part IV of this report, Col. John E. Pickering, Director of Medical Research in the USAF School of Aviation Medicine, Brooks Air Force Base, Tex., said:

> * * * we have seen over the past 2 years a tremendous growth in our national biomedical space effort. Nearly every institution and industrial organization has some facet of a space medicine research effort. Additionally, practically everyone in this audience has a personal interest in space research or is a member of one or more space committees. Yet with all of this, we are still without a central coordinated space biology research team. Programs are being pursued on a near individual basis without benefit, in many instances, of advice and experience of interested and knowledgeable people. As a consequence we are in fact diluting our national talent to such an extent that the future may not hold much more hope for real success and understanding than the past, and a record of the past is not necessarily one of sound and rigorous scientific achievement * * *.

PLANS FOR FUTURE COORDINATION NOT WORKED OUT

There is little present evidence to indicate a well-conceived plan for future coordination between NASA and the Department of Defense in the life sciences in terms of the specific problems raised by the NASA Bioscience Advisory Committee referred to above. Part IV of this report contains extensive testimony that relates to the possible amendment of the National Aeronautics and Space Act of 1958, which would result in abolishing the Act's two statutory coordinating bodies, the National Aeronautics and Space Council and the Civilian-Military Liaison Committee. The testimony also indicates, however, that the Civilian-Military Liaison Committee has not been utilized to effect coordination between NASA and the Department of Defense.

As was pointed out to NASA earlier in the form of a committee question—which is included on page 36 of this report—during fiscal year 1959 the National Science Foundation's annual obligation in support of basic research in the biological and medical sciences was about $20 million, plus an additional $3 million for research facilities in these areas. Other Government agencies also spend substantial amounts every year in the biological and medical sciences. Since much of these supported research programs in the biological and medical sciences have important related application and use in the field of space science it is especially important that NASA's efforts be thoroughly coordinated with those of other Government agencies.

RELATED DIRECTIVES CONCERNING SCIENTIFIC RESEARCH

One of the fundamental directives relating to the coordination of scientific research in the Federal Government—the full text of which is also included in part V of this report—is Executive Order 10521 of March 17, 1954, "Administration of Scientific Research by Agencies of the Federal Government," as amended by Executive Order 10807 of March 13, 1959. Reference is made to the following portions of this directive:

> * * * in order to conserve fiscal and manpower resources, it is necessary that Federal scientific research programs be administered with all practicable efficiency and economy; and
>
> * * * the National Science Foundation has been established by law for the purpose, among others, of developing and encouraging the pursuit of an appropriate and effective national policy for the promotion of basic research and education in the sciences * * *
>
> SEC. 6. The head of each Federal agency engaged in scientific research shall make certain that effective executive, organizational, and fiscal practices exist to ensure (a) that the Foundation is consulted on policies concerning the support of basic research * * *
>
> SEC. 7. Federal agencies supporting or engaging in scientific research shall, with the assistance of the Foundation, cooperate in an effort to improve the methods of classification and reporting of scientific research projects and activities * * *

SEC. 8. To facilitate the efficient use of scientific research equipment and facilities held by Federal agencies:

(a) the head of each such agency engaged in scientific research shall, to the extent practicable, encourage and facilitate the sharing with other Federal agencies of major equipment and facilities; and

(b) a Federal agency shall procure new major equipment for facilities for scientific research purposes only after taking suitable steps to ascertain that the need cannot be met adequately from existing inventories or facilities of its own or of other agencies.

In this same regard, NASA also should utilize to the maximum possible extent its membership on the Federal Council for Science and Technology—established by Executive Order 10807 of March 13, 1959, as an outgrowth of the report of the President's Science Advisory Committee titled "Strengthening American Science." The following portions of the Executive order—reproduced in part V of this report—are especially pertinent:

SEC. 2. FUNCTIONS OF COUNCIL. (a) The Council shall consider problems and developments in the fields of science and technology and related activities affecting more than one Federal agency or concerning the overall advancement of the Nation's science and technology, and shall recommend policies and other measures (1) to provide more effective planning and administration of Federal scientific and technological programs, (2) to identify research needs including areas of research requiring additional emphasis, (3) to achieve more effective utilization of the scientific and technological resources and facilities of Federal agencies, including the elimination of unnecessary duplication, and (4) to further international cooperation in science and technology. In developing such policies and measures the Council, after consulting, when considered appropriate by the Chairman, the National Academy of Sciences, the President's Science Advisory Committee, and other organizations, shall consider (i) the effects of Federal research and development policies and programs on non-Federal programs and institutions, (ii) long-range program plans designed to meet the scientific and technological needs of the Federal Government, including manpower and capital requirements, and (iii) the effects of non-Federal programs in science and technology upon Federal research and development policies and programs.

(b) The Council shall consider and recommend measures for the effective implementation of Federal policies concerning the administration and conduct of Federal programs in science and technology.

A further measure of coordination, which NASA has signified an intention of joining, is the Bio-Science Information Exchange. (See p. 37.) This organization—described in part V of this report—performs a unique role in providing a variety of information about research grants in the biosciences to a multiplicity of research-sponsoring organizations in agencies of the Federal Government.

ADVISORY GROUPS

Parts II, III, and V of this report show that many of the Nation's most competent life scientists are currently available to the Government through a variety of advisory boards and committees. It should be noted that advisory bodies generally meet infrequently and lack day-to-day participation in the operating decisions of the organizations they advise. One of the reasons for the frequent practice of overlapping membership on these advisory bodies apparently is to assist in communication and coordination among the network of such organizations.

It is also indicated in part V of this report that two space-oriented advisory groups are administered by the National Academy of Sciences-National Research Council under contract. One, the Space Science Board—an advisory and consultative body covering all fields of space science—is supported jointly by NASA and the National Science Foundation at a total annual reported cost of $179,000. The other, the Armed Forces-National Research Council Committee on Bio-Astronautics, has been supported in equal annual amounts of $25,000 each by the Departments of the Army, Navy, and Air Force. There is some speculation that the Department of the Army might withdraw its membership and support from the Committee because it is no longer considered to have a "role" in space.

In terms of relatedness of these two advisory bodies to space medicine, the Space Science Board has 1 panel—out of a total of approximately 12—devoted to this general area, and the Committee on Bio-Astronautics has all of its nine panels devoted to it. If NASA continues to enlarge its responsibilities in the space medicine field, it should consider the possibility of supporting both organizations since both could apparently contribute to NASA's program. Such consideration should also include the feasibility of combining the two groups, both of which are administered by the National Academy of Sciences-National Research Council, in order to promote closer integration and communication between the organizations and their sponsoring agencies.

OVERALL PROBLEM AND ITS NEEDS

In summation, the question raised by the Committee on Aeronautical and Space Sciences, and reflected in this report, is that it is concerned as to whether in establishing the NASA Office of Life Science Programs adequate consideration was given to: (1) How existing space-related life science programs, resources, and facilities in other Government organizations could be utilized to the maximum extent possible; (2) the long-range implications of competition between Government organizations for limited numbers of available life scientists; and (3) how required coordination could be undertaken among life science programs to avoid unnecessary duplication of effort.

The Committee believes that there is a definite need for the issuance of a policy statement or suitable set of guidelines by NASA and other space-related Government life science organizations, including the military services in the Department of Defense, showing how they may

conduct business on a systematic basis so as to insure the achievement of a unified program of maximum coordination and utilization of individual resources and facilities. This would also necessitate an evaluation by the Department of Defense as to which of its life science programs have purely staff or organizational missions, which are related to or support technology, and what overall proportion of such facilities could be made available in support of NASA requirements. The long leadtime required in scientific research and development necessitates sound forecasting for meeting future needs adequately.

There is little justification for isolating related life science programs by agency and assigning them "civilian" or "military" labels. Their relatedness in program content should be reflected in a coordinated program execution that utilizes fully all resources available.

2. The Objectives of Space Research in the Life Sciences

* * * because man will fly into space—there are * * * a number of things that we must find out.

We have to find out factors that affect the biological process, the living organism of man himself; how he reacts to this space environment; which is a very alien environment as compared with this atmosphere that we live in.

Furthermore, we must ascertain before we send a vehicle into space that it is as nearly a perfect piece of mechanism as anything man has ever built; because, once you launch a spacecraft with a man in it in the direction of the Moon or of any planet, everything has to work. You do not turn around simply and come back if something fails. You do not drift and eventually drift to a friendly shore. You obey the immutable laws of motion and you tend to go out.

So we are going to have to insure to the highest extent possible that every piece of equipment that we put in the craft is proven and capable of working for the months or even years—in the case of some planetary expeditions—that will be required.

There are two ways you can do this, and we shall use both of them:

We shall utilize facilities, research facilities, on the ground so far as possible, both to study the effects of simulated environments on man and on the technological articles; but this total space in which we must fly has vacuums that are very difficult to achieve completely upon the Earth.

It undergoes radiations, particle encounters, micrometeorite encounters, a great number of factors that will be difficult to represent in whole in an Earth laboratory.

Hence we feel that an integral part of the total space exploration and research phase is going to be the placing of satellites in orbit about the Earth that are actually flying in the total-space environment that we are going to have to encounter, and in which we can study both the biological and technological processes involved.

* * * * * * *

54232—60——2

This testimony on February 20, 1959, by DeMarquis D. Wyatt, technical assistant to the Director of Space Flight Development of the National Aeronautics and Space Administration, served to preview the Senate Committee on Aeronautical and Space Sciences on the future role of the life sciences in NASA's space sciences program.

The objectives of space research in the life sciences include (1) determination of the effects on living organisms of extraterrestrial environments; (2) investigation of the existence of extraterrestrial life; and (3) achievement of scientific and technological advances required for manned space flight and exploration, including extensive basic research and development in a broad variety of biological, psychological, and medical programs. The broad spectrum of life sciences activities spans basic laboratory research at the one extreme and practical application testing and operational evaluation of hardware at the other.

For the purposes of this report the life sciences are meant to include biological, psychological, and medical programs related to, or being carried on in support of, aeronautical and space activities. It is a field abundant with terminology in which the following identical or similar expressions are frequently observed: aerospace medical sciences; aerospace biosciences; aerospace life sciences; bioastronautics; aviation and space medicine; space biology; and human factors.

3. The Example of Project Mercury

A program of highest priority now being conducted by the National Aeronautics and Space Administration is Project Mercury, the manned satellite program. The objectives of Project Mercury are to (1) place a manned space capsule in orbital flight around the Earth, (2) investigate man's performance capabilities and ability to survive in a true space environment, and (3) recover the capsule and the man safely. Project Mercury is a national effort of the United States, conceived and organized to send man on his first short step into space. The NASA Space Task Group located at the Langley Research Center, Hampton, Va., is administering Project Mercury.

The McDonnell Aircraft Co. of St. Louis, Mo., was selected to develop and manufacture the Mercury manned satellite capsule, which is bell shaped like a round television tube about 6 feet at the base and about 9 feet tall. The capsule will be wingless, have an extremely blunt leading face covered with a heat shield, and have high aerodynamic drag; it will be subject to various combinations of acceleration, heat loads and aerodynamic forces during boost and atmosphere-reentry phases. It is planned that an Atlas intercontinental ballistic missile rocket booster would launch the manned capsule in a circular orbit around the Earth, at an altitude of between 100 to 150 miles. Upon completion of three orbits around the Earth, descent from orbit would take place by use of retrothrust rockets in the capsule system. After being slowed down by aerodynamic drag, parachutes in the capsule system will billow out and further reduce descent speed, and recovery of the capsule could be made on land or water.

The Mercury capsule would be guided into the desired orbit through ground-based and booster equipment after which ground and capsule devices would determine the orbital path in flight. Each orbit of the

capsule around the Earth would take about 90 minutes. Inside the Mercury capsule the astronaut, wearing a pressurized flight suit, would be supported on a couch tailored to the exact contours of his body which would enable him to withstand the forces of acceleration on takeoff and reentry. Food and water would be available to the astronaut during orbital flight, and the capsule would be subject to controlled pressure, temperature, and atmosphere composition.

The astronaut would have contact through voice communication with ground stations during flight. Capsule instrumentation would include two-way radios, receivers for command from the ground, telemetry equipment for transmission of data from the capsule to ground stations, and radio tracking beacons. Information on the astronaut's physical condition would be telemetered to ground stations. Other equipment would evaluate the astronaut's reaction to space flight, measure and monitor the internal and external capsule environment, and make scientific observations.

The astronaut would have the option of using manual or automatic control of the capsule during orbital flight. A control system of capsule attitude sensors, electronic stabilization devices, and reaction controls would be incorporated in the capsule. The reaction control would maintain the capsule in a specified orbital attitude and establish the proper angle for firing of the retrothrust rockets for reentry into the atmosphere, or for an unplanned termination of the mission. During manual control of the capsule the astronaut would be able to see portions of the earth and sky which would enable him to position the capsule to the desired orbital attitude.

Upon a signal initiated by either the astronaut, an automatic device within the capsule, or by a command link from ground control, the Mercury capsule's retrothrust rocket system would supply sufficient impulse for reentry into the atmosphere in less than one-quarter of an orbital revolution. This control over the capsule's point of reentry into the atmosphere would enable the landing area to be largely predetermined. After the capsule has landed recovery aids would include tracking beacons, smoke bombs, dye markers and other devices.

Among the Project Mercury safety control features are an emergency system enabling the astronaut to escape if anything goes wrong during launching, an escape-system separation of the capsule from the booster in an emergency situation before orbital altitude is reached and after the capsule is in orbit the ability of the astronaut to reenter the atmosphere at any time by activating the retrorockets. Project Mercury includes ground testing, development and qualification flight testing, and astronaut training—orbital flight of the manned space capsule would be dependent upon a logical buildup of vehicle capabilities and scientific data.

SELECTION OF MERCURY ASTRONAUTS

Because many of the unusual conditions expected in space flight are similar to those experienced by miltary test pilots, NASA went to this field for volunteers for the astronaut program. The general requirements were: possession of a bachelor's degree or equivalent in engineering or the physical sciences; graduation from a military test pilot school; 1,500 hours of jet flying time; under age 40; and 5 feet 11

inches in height or less. The educational requirement was set because of the variety of scientific and technical problems that would confront the astronauts throughout the program.

A preliminary screening of records indicated that more than 100 active graduates of military test pilot schools would qualify under these requirements. It was found unnecessary to contact all of them, because of the first 69 called to Washington to hear the Mercury project outlined, 80 percent volunteered. All were of such high caliber that selection was difficult. Through individual interviews and suitability discussions to determine motivation, experience and technical background, a group of 32 was selected to proceed further in the program. The 7 Mercury astronauts finally selected come from this group of 32.

From Washington, the selection schedule took the pilots first to Lovelace Clinic in Albuquerque, N. Mex., and then to Wright Air Development Center Aeromedical Laboratories, Wright-Patterson Air Force Base, Ohio. At Lovelace, candidates were given exacting physical examinations. At WADC, the Air Force, with the assistance of Army and Navy specialists, assessed candidates in the psychological and stress tolerance areas. The selection process ended at the NASA Langley space flight activity, where final evaluation was undertaken by a group representing both medical and scientific professions.

MERCURY ASTRONAUT TRAINING PROGRAM

The astronauts are training at a number of locations throughout the country, including the Wright Air Development Center; Naval Air Development Center, Johnsville, Pa.; Atlantic Missile Range, Cape Canaveral, Fla., and at other biomedical centers. The home of the astronauts, and the location of the NASA Space Task Group is at the NASA Langley Research Center facility.

The initial phase of the astronaut training program is broken down into six areas of activity:

1. *Education in the basic sciences.*—Essentially an academic educational program, this area includes instruction in astronautics, particularly ballistics, trajectories, fuels, guidance, and other aspects of missile operations, basic aviation medicine and orbital flight hygiene, the space environment, astronomy, meteorology, astrophysics, and geography, including the techniques for making scientific observations in these areas.

2. *Familiarization with the conditions of space flight.*—This phase of training is designed to familiarize the astronauts with the heat, pressure, G force levels and other special conditions of space flight. It includes periodic simulated flights in centrifuges and pressure chambers, weightless flying, training in human disorientation devices, the development of techniques to minimize the effects of vertigo, and experiments with high heat environments.

This part of the training program will provide data on the ability of the astronaut to contribute to system reliability under the conditions to be encountered during flight, the psychological and physiological effects of the normal and various emergency conditions which may be encountered during flight, and the requirements for the sup-

port and restraint systems, the environmental control system, and the crew space layout.

3. *Training in the operation of the Mercury space vehicle.*—The objective of this segment of the program is to provide a thorough knowledge in the operation and maintenance of the Mercury vehicle and its component subsystems, with particular emphasis being placed on the use and maintenance of the scientific instruments and life-support equipment.

4. *Participation in the vehicle development program.*—Each of the astronauts is assigned to a system or subsystem of the Mercury vehicle. In this work, he will acquire specialized knowledge of value to the entire group. This information is exchanged in a series of informal seminars.

Actual work on the vehicle development program by the astronauts will provide limited augmentation of the Space Task Group staff as well as providing them with an intimate knowledge of all aspects of the Mercury vehicle itself.

5. *Aviation flight training.*—The Mercury astronauts will continue to maintain their proficiency in high performance aircraft in an aviation flight training program. Continued operation of high performance aircraft will give them additional altitude acclimatization, instrument flight training and the physiology of high altitude, high speed flight.

6. *Integration of astronaut and ground support and launch crew operation.*—Familiarization with the operation of ground support equipment and launch crew operations will be accomplished in coordination with the agencies providing boosters and launch facilities. Training in the operation and use of ground support equipment and observation of launch operations will provide the astronauts with complete knowledge of the launch phase of Mercury flights.

Existing research, development, training and test facilities of the armed services, industry and educational institutions throughout the country will be utilized for maximum effectiveness at minimum cost. A number of experts in many of the scientific and technical subject areas will give lectures to the astronauts during their educational program.

The concentrated astronaut education program began with overall program orientation briefings by members of the Space Task Group staff. While assigned to the Langley facility, the Mercury astronauts will work as integrated members of the NASA Space Task Group.

Each of the Mercury astronauts has been detailed to the NASA by his respective military service but is still considered to be on active duty and is receiving military service pay. The astronauts will remain on duty with NASA on a full-time basis.

MERCURY BIOMEDICAL FACTORS

The various biomedical programs undertaken in connection with Project Mercury are also aimed at the overall guiding philosophy of the Mercury undertaking: That there be an adequate margin of safety for the Mercury astronauts and that the risk hazard should be no greater than in test pilot operations with experimental aircraft. Brig.

Gen. Don D. Flickinger, staff surgeon and Director of Life Sciences in the Air Research and Development Command Headquarters, Department of the Air Force, who is closely associated with Project Mercury, stated before this committee on April 9, 1959:

> * * * We attain this degree of safety for our astronauts by a very rigid selection, test, and qualification of both the hardware components involved in the safety of the astronaut, and of course, the human component as well. Both are equally important.

General Flickinger went on to mention some of the hazards involved in Project Mercury, the information at hand about human tolerances to these hazards, and the engineering techniques and methods of maintaining such hazards within known tolerances. He stated that the factors for crew safety and effectiveness in the Mercury mission were divided into two groups: critical factors and uncritical factors. These are listed and defined as follows:

Critical factors for crew safety and effectiveness

1. *Dynamic forces.*—Forces imposed upon the human by the vehicle itself in achieving orbital velocity and in reentry and landing.

2. *Life support system:*—All components that give the human the basic requirements during the period of the orbital mission, including food, water, pressure, oxygen, and maintain potential noxious gases below the atomic level. (The Mercury capsule will have a 100 percent margin of safety in that it can sustain the astronaut for 48 hours, if necessary, instead of the planned maximum of 24 hours.) Many aspects of the life support system requirements are minimal because of the short duration of the flight as compared with what they would have to be for extended space travel.

3. *Medical monitoring.*—To know how the human being is functioning and also how the equipment furnishing his vital needs is functioning.

Uncritical factors for crew safety and effectiveness

These factors have been referred to as the great mystery of manned space flight, because they cannot be fully duplicated, apart from experiencing actual orbital flight. The factors are considered as uncritical only in terms of the Mercury vehicle and scheduled mission profile which basically provides that (*a*) should the pilot be disabled or unable to perform when exposed to the altered force environment the vehicle can be completely controlled by ground stations, (*b*) the orbital apogee will remain well below the proximal Van Allen lobe of radiation, and (*c*) maximum duration of time in orbit will not exceed 18 to 24 hours.

1. *Weightlessness.*—A condition that exists when the outward centrifugal force of the vehicle equals the pull of gravity. It does not appear to be a handicap for short-term manned flight, but long-range flight could be more serious in resultant physiological changes.

2. *Isolation and confinement.*—The psychological aspects on the individual of isolation, confinement, and complete separation from all terrestrial things.

3. *Cosmic radiation.*—The Mercury orbit is approximately 100 to 150 miles above the Earth, below the hazards of the great radiation

belts that affect deeper space probes. From known measurement a Mercury pilot in orbit for even as long as 48 hours would receive about 45 milliroentgens of radiation, which is well within the tolerance dose.

4. Advanced Biomedical Programs

On April 9, 1959, Dr. Douglas L. Worf, Chief of Biology and Life Support Systems, gave the following testimony before this committee concerning NASA's advanced biomedical programs.

* * * * * * *

Dr. Worf. * * *

My discussion will be on advanced medical programs. General Flickinger just spoke to you about the problems that we expect to experience in the short-term flights, such as Mercury. In my discussion here I will try to stress the biological problems that we will get into when man is capable of occupying space, planets, or the Moon, for prolonged periods.

[Charts referred to appear on pp. 20–24.]

BIOMEDICAL CONSIDERATIONS—LONG-TERM FLIGHTS

One of the most challenging problems is to supply the man with adequate nourishment, oxygen, water, and clothing over these prolonged periods without unduly penalizing the usefulness of the mission. [Chart 1.]

Another problem that will arise in prolonged flights, at least one that we will have to anticipate and make provisions for, is chronic and acute toxicity. Man, himself, releases certain toxicants after a period of time. Carbon dioxide is one. It is possible also that the materials inside the capsule, even the paint or perhaps a malfunction of the electronic components, might produce a toxicant material. This is something that we have to look into continually, all aspects of the materials of construction in the extended use of the capsule.

Sanitation is a problem, particularly in the weightless state, how are we going to handle human wastes so that the man will not become toxic and a hazard to himself in a space capsule?

Regarding the radiation problem, General Flickinger briefly discussed this for the short-term flight and stressed that this does not appear to be a problem. I will go into the the aspects of radiation for extended manned space flight, in more detail later. The sources of radiation that man will be exposed to are cosmic radiation, the trapped radiation in the great radiation belt; you probably have heard discussions on this earlier, I will elaborate on it from the standpoint of hazard to man. Eventually it is expected that man will utilize nuclear components either for power or propulsion, and provisions must be made to protect him from this manmade nuclear radiation.

Physiological stresses—this is not intended to be complete—but I have listed several stresses that will have to be considered by the biomedical community.

Temperature, high temperature during reentry into Earth's atmosphere, entry into planet's atmospheres or high and low temperature in long flights, say between the Earth and the Moon or Mars is a consideration that the engineers and biologists must take into account in the design of a space capsule.

Weightlessness is a problem that is unique to space. Here again General Flickinger noted that weightlessness doesn't appear to be a serious handicap for short-term manned flights, but it is quite possible that physiological changes in the man will occur in prolonged, extended flights.

Psychological problems may turn out to be the real concern in prolonged flights. The fear of an initial launching, the psychological problems pertaining to extended flight when we have several people in a cramped capsule. Disorientation and isolation problems are also to be considered in the psychological aspects of space flight.

MANNED ORBITING SPACE LABORATORIES

This chart [2] gives the future plans for placing man in space and in manned orbiting space laboratories. The detailed talks given earlier dealt with the Mercury-type booster vehicle which is capable of putting about 2,500 pounds in space in a 150-mile orbit. In several years, we anticipate placing two men in space for a 2-week period. Then we will get into a still more advanced design, phase 3, which will permit several men to be placed in an orbit for several weeks. This will be accomplished by a cluster of the Mercury type vehicle.

Finally, we get into the development of a very large vehicle, permitting a permanent space station to be placed in orbit containing half a dozen scientists or engineers to be placed in space, enabling them to make observations on technological, scientific and biological observations over a prolonged period of time.

One of the most challenging problems, as I mentioned earlier, is to keep man adequately supplied with food, and to keep him alive and well.

FOOD, OXYGEN, WATER REQUIREMENTS

The chart [3] I have here shows the daily metabolic turnover of a man weighing about 154 pounds. He requires about 2 pounds of oxygen per day; about 5 pounds of water, and a little over a pound of solid food. That is his input. His output would consist of about 2 pounds of carbon dioxide, about 6 pounds of water, and just a small amount of solids, urea, and minerals.

It becomes obvious, by using a little arithmetic that man is going to eat the equivalent of his weight in about 20 days. In less than a year, he will have consumed about a ton of oxygen, food, and water. This gets to be prohibitive in terms of permissible payload to carry adequate food supplies along. So we will have to resort to utilizing some of this output for de-

veloping an input. In other words, we will have to regenerate some of the human waste. We would like to avoid this if at all possible, and are trying to develop every possible idea to extend the period of time where we will not have to regenerate any part of the human waste for food.

FOOD REGENERATION

This curve [chart 4] shows the pounds of food required over this period of time of flight for one man. No regeneration is required of human waste. Now, in order to extend this line beyond this 4-week breakoff period where we will have to begin at least the partial regeneration of human waste, we are looking into various chemicals and methods for extending this period of time.

One method would be to utilize potassium superoxide. This is a chemical which has the interesting characteristic of absorbing the carbon dioxide exhaled by man at the same time releasing oxygen. We also might look into such radical ideas as developing and utilizing some of the structural components of the capsule itself as edible material. This will not extend the nonregenerative period much beyond 4 to 6 weeks, however, after which we will have to consider the possibility of utilizing some human output for replenishing input requirements.

The water of elimination appears to be one of the first that we will work with by the selective use of ion exchange resins. It is anticipated that we can make the water potable or perhaps use it for dehydrated foods. This will extend the flight period to about 3 months, at which time we are going to have to consider a completely regenerative system, that is, one utilizing all human wastes.

COMPLETE FOOD, OXYGEN, WATER REGENERATION

This chart [5] illustrates one suggestion for undertaking this procedure. We have here a cycling system where man's wastes are used for food by what we call an algal system. This algal system not only uses certain human wastes, the CO_2, the carbon dioxide, and certain organic solids, but also requires solar radiation for its growth.

As algae grows, they release oxygen, and this is, of course, one of the requirements of man. Also, the algae themselves provide a nourishing food with the essential amino acids, protein, and carbohydrates requirements.

Therefore, this is one area that we are looking into very seriously, and perhaps in about 5 years, if our program progresses as we expect, we will have a prototype of a completely closed system available for testing in space.

Some of the problems we expect to investigate in space by the use of this system is the effect of radiation on these algae. If radiation causes a bad mutation, it might very well kill off the algal system. If this should occur while man is in orbit

between the Earth and Mars, this, of course, would be fatal. Temperature also affects their growth, so we have to select an algal system very carefully.

RADIATION HAZARDS

Another problem that I mentioned to you just a moment ago is the radiation to which the pilot may be exposed. Such radiation affects unicellular organism algae, which I have here in this test tube. This radiation not only affects these algae system, causing mutations, but, as you well know, radiation affects man, too, especially ionizing radiation, as opposed to ultraviolet, which is regarded as one of the non-ionizing radiations.

The most severe situation we have to face is the so-called great radiation belt discovered by Van Allen in his experiments with Pioneer III and earlier experiments with Explorer.

It appears now that this will not be a serious bottleneck to man's space flight, but it is another parameter we must consider. It will certainly not be a problem with the earlier Mercury flights, since they will be well below the point at which the first belt begins, about 1,500 miles above the Earth.

We can select most of our missions to orbit below that potentially hazardous region, or we can select them so that they will be between these belts where there is less radiation.

I will not attempt to go into detail regarding this chart on the great radiation belt. I think you have had an earlier presentation on these radiation belts, but I want to bring out a few points on how we are considering this radiation insofar as future manned space flights are concerned.

It is possible also that in the escape velocity the pilot would go directly through this belt without harmful radiation. We expect it would take about a half hour at this speed to get through the belts. Assuming that the charged particles are electrons, the pilot would get only about 5 rem per hour. This is the amount of radiation which is allowed per plant worker per year by the Atomic Energy Commission.

Of course, if they are protons, the pilot would get considerably more. He would get 50 rem, or 10 times that amount; but again, this is not regarded as a permanent physiologically damaging dose but this amount would certainly not be permitted for the world population. This so-called permissible level for you and me and the world at large is only 0.3 of a rem per year. The lethal dose for 50 percent of exposed persons (L.D. 50) is 450 rem, and if a passenger in these belts was unshielded for a period of 4½ hours, assuming charged particles are protons, he would receive L.D.–50. It would require several days to receive this L.D.–50 dose if corpuscular radiation were electrons.

The amount of shielding required, by the way, is about an inch of this plastic or about a half inch of aluminum to protect him indefinitely if he is in these belts.

WEIGHTLESSNESS

Now, another problem that we have to consider is living under a weightless condition. General Flickinger spoke to you about the fact that this is not regarded as a hazard for short-term flights. For long-term flights we anticipate certain problems. It will be an annoying situation to say the least. A man will have to develop new techniques for just getting around and performing useful functions. He will be required to develop new ways of walking, handling himself, and getting around.

In a weightless state the feeding problem is difficult, especially with liquids. Since liquids will not weigh anything, the pilot will have to use a special squirt bottle to get liquids into his mouth. He will probably not eat solid chunks of meat because this is apt to cause regurgitation and choking which could be fatal. So that in the weightless condition, the pilot may be required to use highly nutritious semifluids.

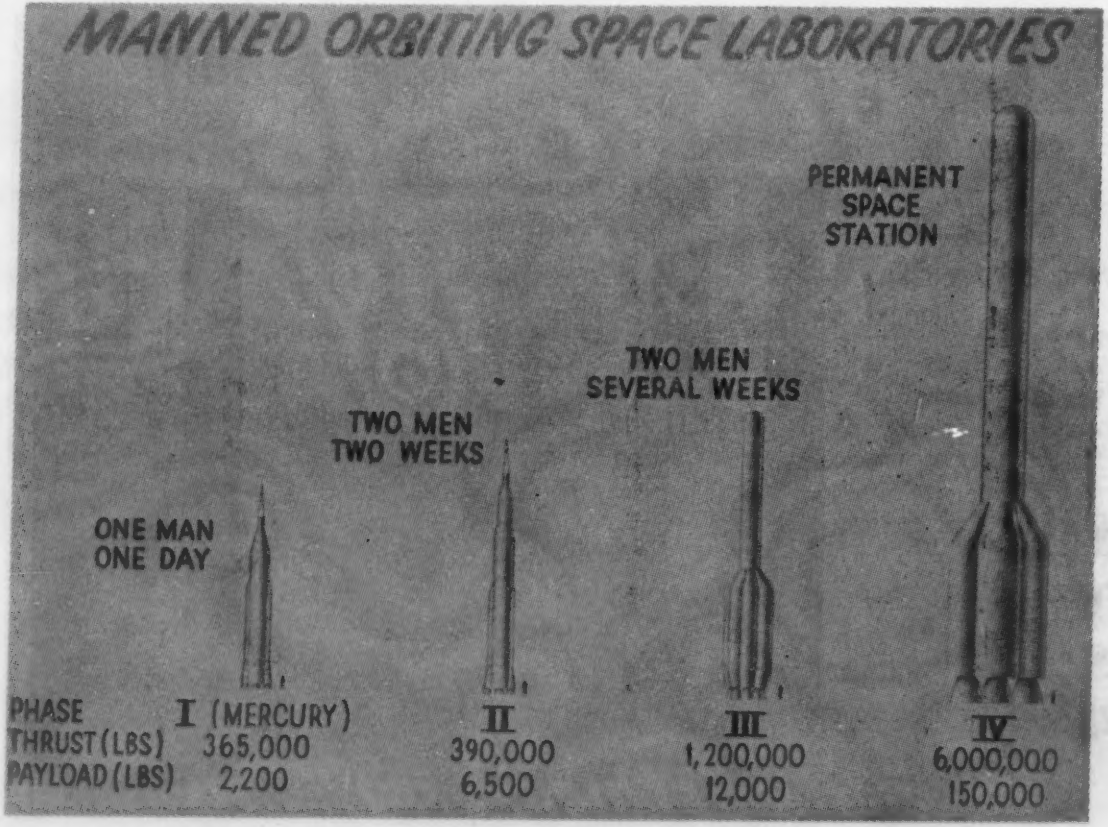
Storage and handling have to be considered; dispensing liquids, as mentioned; sanitation; and we will have to develop esthetic accessory equipment for handling and disposing of human wastes.

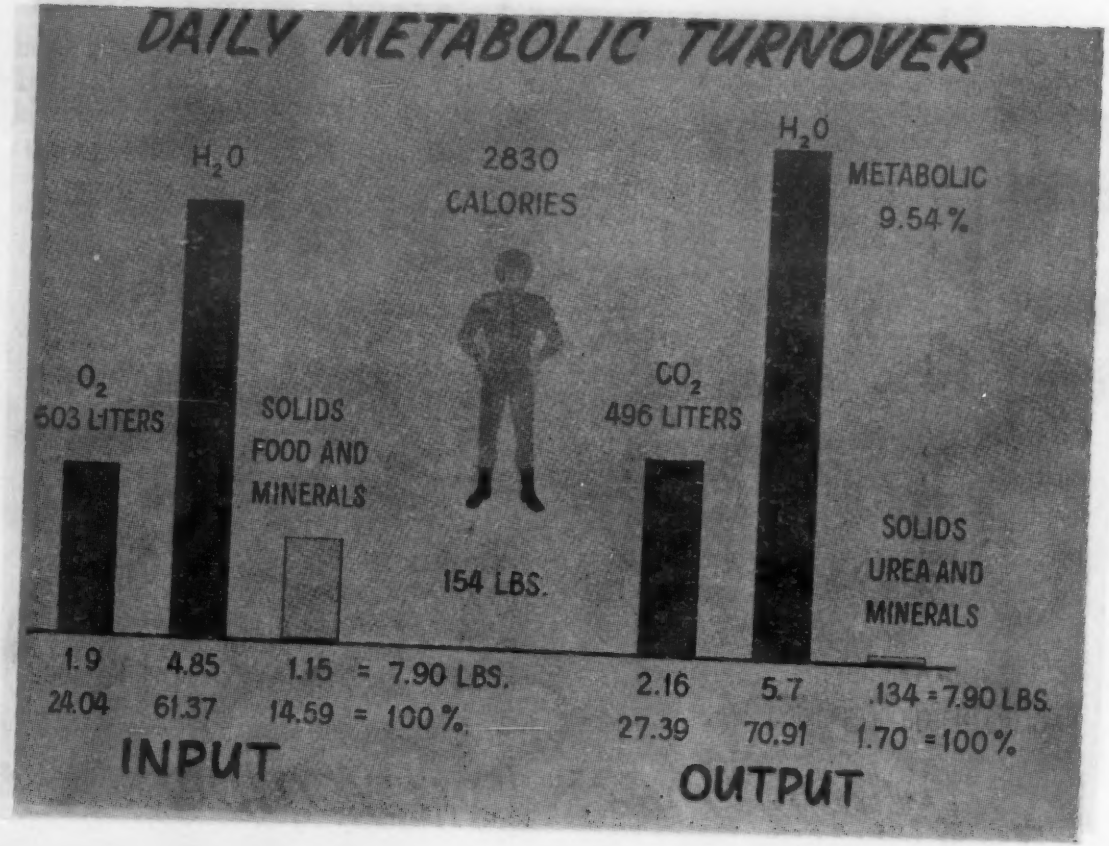
One of the ways for circumventing the problems in a weightless state would be to apply to the vehicle and its passengers an artificial or a simulated gravity. This is simply accomplished by rotating the vehicle. We can control the gravitational force to the required amount in this fashion.

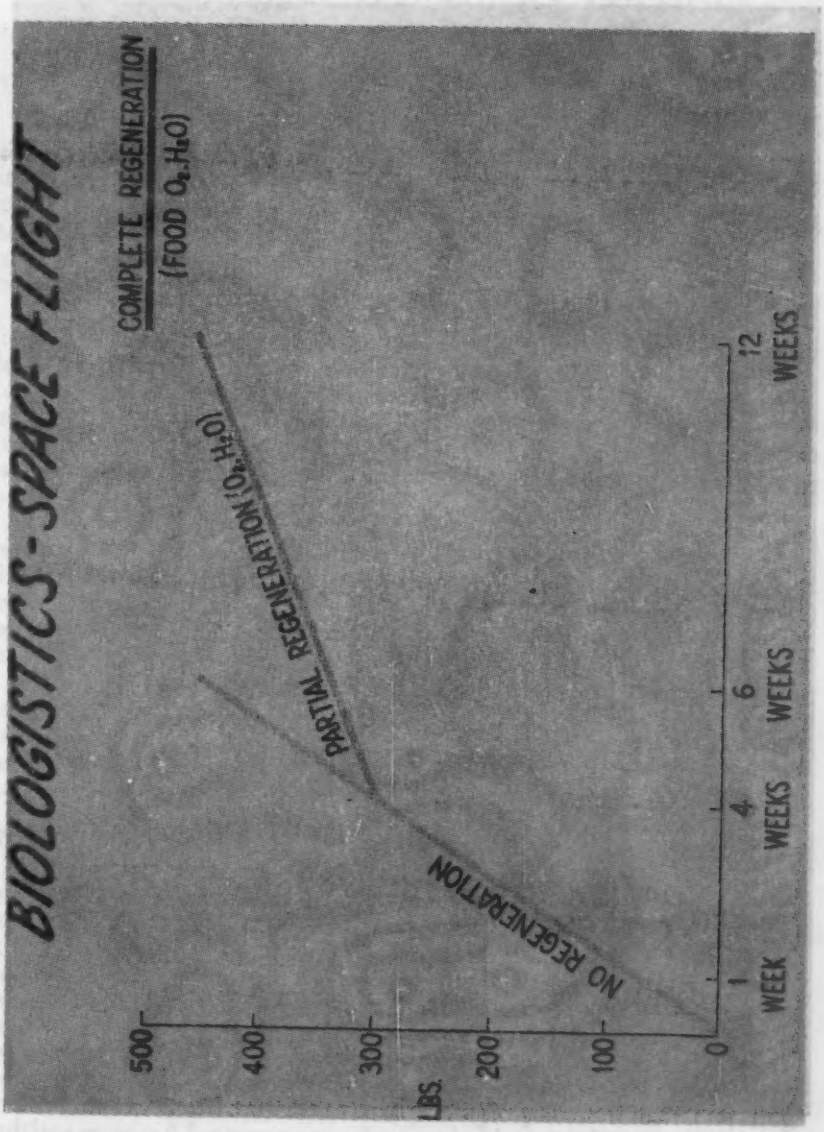
Well, I have not attempted here to give you the full picture of the problems that we are facing with long-term flight. I think that our main objective here, I can state in summary, is to make space life at least tolerable for man.

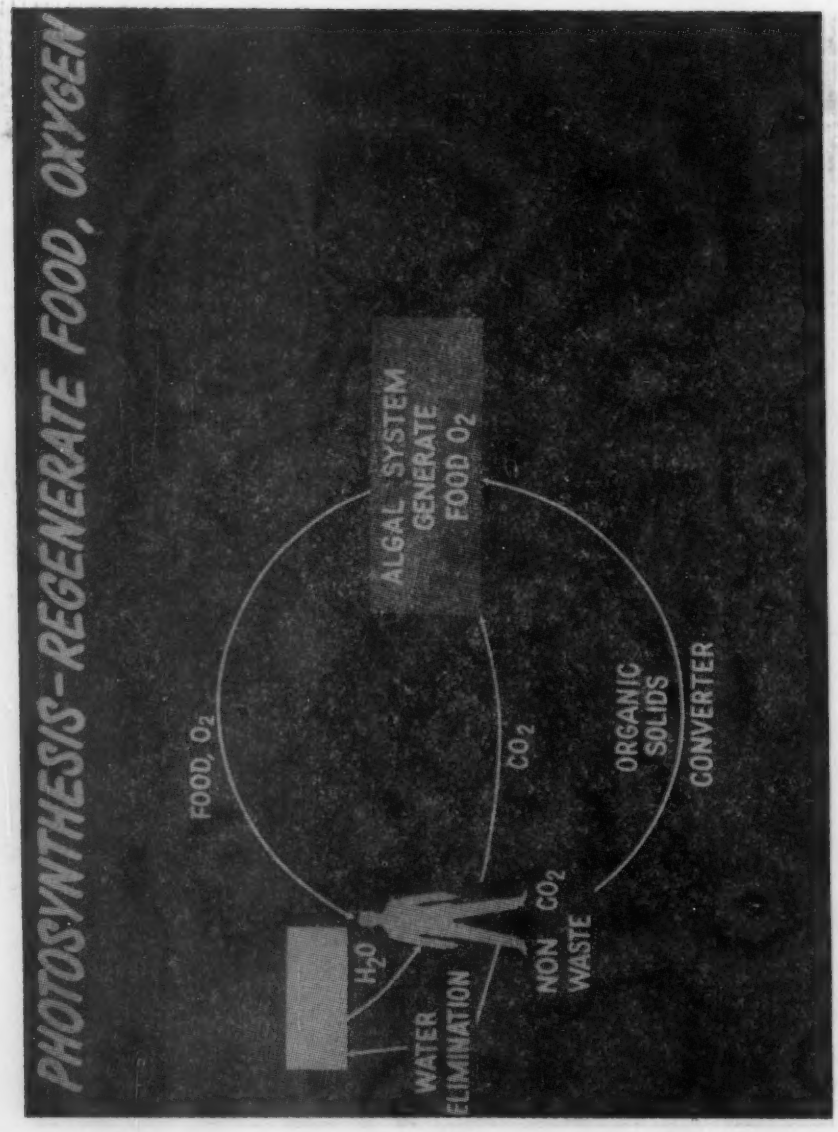
* * * * *

BIO-MED CONSIDERATIONS
LONG DURATION FLIGHTS
BIOLOGISTICS
FOOD
OXYGEN
WATER
TOXICOLOGY (IN CAPSULE)
CARBON DIOXIDE, MOISTURE
SANITATION
RADIATION
COSMIC
GREAT RADIATION BELT
NUCLEAR-MAN MADE
PHYSIOLOGICAL STRESS
TEMPERATURE
HIGH ACCELERATION
WEIGHTLESSNESS
PSYCHOLOGY
ANXIETY
DISORIENTATION
ISOLATION


MANNED ORBITING SPACE LABORATORIES
PERMANENT SPACE STATION
TWO MEN SEVERAL WEEKS
TWO MEN TWO WEEKS
ONE MAN ONE DAY
PHASE I (MERCURY) II III IV
THRUST (LBS) 365,000 390,000 1,200,000 6,000,000
PAYLOAD (LBS) 2,200 6,500 12,000 150,000


DAILY METABOLIC TURNOVER
H_2O
2830 CALORIES
H_2O
METABOLIC 9.54%
O_2 603 LITERS
SOLIDS FOOD AND MINERALS
CO_2 496 LITERS
SOLIDS UREA AND MINERALS
154 LBS.
1.9 4.85 1.15 = 7.90 LBS.
24.04 61.37 14.59 = 100%
INPUT
2.16 5.7 .134 = 7.90 LBS.
27.39 70.91 1.70 = 100%
OUTPUT


BIOLOGISTICS - SPACE FLIGHT
COMPLETE REGENERATION
(FOOD O_2, H_2O)
PARTIAL REGENERATION (O_2, H_2O)
NO REGENERATION
LBS.
500
400
300
200
100
0
1 WEEK
4 WEEKS
6 WEEKS
12 WEEKS


PHOTOSYNTHESIS-REGENERATE FOOD, OXYGEN
ALGAL SYSTEM GENERATE FOOD O_2
FOOD, O_2
CO_2
ORGANIC SOLIDS CONVERTER
NON CO_2 WASTE
H_2O
WATER ELIMINATION

PART II. NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

1. Background, Organization, and Activities in the Life Sciences

The National Advisory Committee for Aeronautics (NACA), predecessor organization of the National Aeronautics and Space Administration, began studies of "human factors" in 1943. Activity in this area was initiated in response to problems arising with the development of high performance aircraft in World War II necessitating integration of man with increasingly complex systems for the performance of flight missions.

The experimental X–1 aircraft and its successors have added significantly to the magnitude of pilot control problems. This led to the development of ground-based flight simulators by the NACA. Beginning in 1950 a program was expanded on a small scale at the NASA Langley and Ames Research Centers which includes computor programed static and dynamic flight simulation as well as variable stability experimental aircraft to test human performance as a link in aircraft control systems.

The advent of space exploration late in 1957 and the initiation in October 1958 of NASA's high priority Project Mercury, designed to place a man in orbit around the earth and to recover him safely, brought human problems associated with space exploration into sharp focus and thereby helped to delineate broad requirements for future activities in this area.

It was the interpretation of the National Aeronautics and Space Administration that in accord with the functions given it in the National Aeronautics and Space Act of 1958 [that "activities in space should be devoted to peaceful purposes for the benefit of all mankind"] in the study of life processes in this newly opened environment a NASA program should constitute a significant part of the total effort.

NASA interpreted its functions as requiring a long-term twofold goal regarding the space related aspects of biology, medicine and psychology. The first is concerned with manned space flight and exploration, necessitating provision of the essentials for survival in the space environment and the means which will allow effective human performance in flight and as a scientific observer. The other major goal is directed toward further understanding of the fundamental laws of nature as they apply to biology and medicine that will result from studies in the space environment, directed at the goal of opening a new dimension for observation of biologic phenomena. The long leadtime required for necessary advances in biotechnology requires continuing effort in a number of problem areas, including man-machine integration, definition of tolerance to combined stresses, development of life support systems, radiation shielding, and provision of adequate escape and protective devices.

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Project Mercury was planned and is now being executed as the first in a number of steps toward manned space flight and exploration. It was recognized that in order to accomplish at the earliest practicable date the assembling and testing of systems and subsystems required for successful manned orbital flight, problem areas such as reliability, tracking, communications, control, reentry, and recovery techniques had to be overcome. Research designed to acquire the basic medical and behavioral information required to meet the physiological and psychological needs for long duration existence and effectiveness in stressful artificial environments necessitates augmentation of investigation in radiology, metabolism, cardiovascular physiology, respiratory physiology, neurophysiology, and psychology. Basic biological studies at a cellular level—concerning the effects of space environments on living organisms and the search for extraterrestrial life—anticipate investigation of the molecular control of cellular activity and of comparative biology on the broadest possible scale. Exposure of living cells and tissues to a wide range of ionizing radiation, weightlessness, high vacuum, temperature extremes, and unusual combinations of elements to be found in remote planetary atmospheres and surfaces could lead to important scientific information.

These broad objectives led to the establishment of the Office of Life Science Programs as a fifth major division of NASA on March 1, 1960. Clark T. Randt, M.D., was appointed Director of this Office which is responsible for NASA activities in biology, medicine, and psychology. Overall guidelines for the NASA Office of Life Science Programs were recommended by the Bioscience Advisory Committee appointed by Administrator T. Keith Glennan in July 1959 to assess the role of NASA in this area. The NASA Bioscience Advisory Committee was apprised of existing aerospace medical facilities, programs, and personnel by representatives of the Army, Navy, and Air Force, who comprehensively described and illustrated activities in this area. Representatives of industry and universities also provided background information for the committee. Their report was submitted to Dr. Glennan in January 1960. The recommendations have provided a broad outline for the Office of Life Science Programs in planning future life science activities.

The stated mission of the Office of Life Science Programs is to provide leadership and integration for a national program in the space-related aspects of biology, medicine, and psychology. This includes research, development, and training in areas concerned with the technologic and scientific problems of manned space flight and exploration, as well as biological investigations relative to the effects of intraterrestrial environments and the search for intraterrestrial life. NASA has indicated that the Office of Life Science Programs would provide a focal point for activities in this area on a national and international scale. It will be concerned with planning and participation in future manned space flight missions; initiation of a planned program of biologic experiments in the upper atmosphere and the space environment; administration of a grant and contract program in universities, industry, and the military service aerospace medical laboratories to support NASA objectives in the life sciences.

A Life Sciences Research Center is planned by NASA to attract and productively utilize the talents of individuals with outstanding scientific potential who would form a small but high-quality nucleus of capability for leadership and integration of a national program, and establish and maintain an appropriate degree of active participation with the physical scientists and engineers in the other operating divisions of NASA. The center would concentrate on the programing and development of biologic experiments in space, basic medical and behavioral sciences, and space-related basic biological research. The dimensions and site of the proposed Life Sciences Research Center are now under consideration by NASA.

ORGANIZATION

The major programs in NASA concerned with biology, medicine, and psychology are manned space exploration, and biological investigations in the space environment. In the first category is the current biomedical effort in Project Mercury. No change in the operation of Project Mercury is anticipated. This is the largest current biotechnologic effort. These biomedical activities include the development and testing of environmental control systems and personal equipment, a training program and simulator experience for the seven astronauts, development of instrumentation for physiological and environmental monitoring, and stress tolerance studies including a series of animal experiments in flight. A program concerned with airplane and manned spacecraft system performance as affected by the presence of a pilot in the control system is continuing at the Langley, Lewis, and Ames Research Centers. These studies are accomplished in static and dynamic flight simulators on the ground and in variable stability experimental aircraft.

PERSONNEL

The biomedical personnel concerned with Project Mercury totals 36. These include four military medical doctors and one military psychologist, all on detached service with NASA. There are 28 engineers and 3 technicians concerned with this activity. They deal with life-support systems, instrumentation for physiological and environmental monitoring, and animal program for experiments in flight, and protective equipment and devices.

In fiscal year 1961, the Office of Life Science Programs anticipates a total personnel complement of 32, of whom 18 [and eventually 60] will be professional staff members. This includes a request for two individuals on detached service from the Department of Defense.

The Office is now being organized to carry out the staff functions necessary for planning future operations in manned space flight missions and biological investigations.

GRANT AND CONTRACT PROGRAM

Inasmuch as there is currently represented in NASA limited capability in biology, medicine, and psychology aside from Project Mercury, sponsored research and development through a grant and contract program in the life sciences is now being carried on with univer-

sities and industry. NASA anticipates that desired projects in the area of biotechnology as now conducted in the military aerospace medical laboratories will be supported by direct transfer of funds from NASA to the Defense Department. The amount of such funds will be determined after detailed consideration of NASA requirements in this area and further review of personnel, facilities, and programs in the service installations.

The grant and contract program of sponsored research and development in the biomedical aspects of Project Mercury for fiscal year 1960 is funded for $2.18 million. Funding of bioscience research in fiscal year 1960 was $1,154,752.

NASA bioscience research grants and contracts

Organization, number and principal investigator	Title	Cost	Starting date	Ending date
1. Yale University, NsG 19-59, Dr. W. Vishniac.	Remote detection of bacteria by automatic observation of changes in exposed culture media.	$4,485	June 1, 1959	May 31, 1960
2. Convair, NASw-50, J. C. Nance.	Study of shielding requirements of manned space systems.	23,730	June 25, 1959	June 24, 1960
3. University of California, NTF-74, Dr. C. Tobias.	Biological systems in interplanetary environments.	90,000	Aug. 21, 1959	Aug. 20, 1960
4. Mine Safety Appliances Research Corp., NASw-90, Dr. J. W. Mausteller.	Exploratory study of potassium and sodium superoxide for oxygen control in manned space vehicles.	73,386	July 1, 1959	June 30, 1960
5. Electric Boat, NASw-95, A. Bialek.	Photosynthetic gas exchanger-algal s. stem.	118,421	Aug. 1, 1959	July 31, 1960
6. Isomet Corp., NASw-117, Dr. W. Ruderman.	Carbon dioxide dissociation for oxygen.	35,000	Sept. 15, 1959	June 15, 1960
7. General Electric, NASw-127, Mr. J. J. Konikoff.	Purification of water from biological wastes.	35,000	Feb. 5, 1960	Feb. 4, 1961
8. University of Minnesota: NASw-70, Dr. A. Brown.	Initiate prototype development for a photosynthetic gas exchanger and a non-CO_2 waste stabilizer for use in space vehicles.	60,000	June 1, 1959	May 31, 1960
NsG-78-60, Dr. A. Brown.	Initiate prototype development for a photosynthetic gas exchanger and a non-CO_2 waste stabilizer for use in space vehicles. Continuation of contract in grant form.	180,000	June 1, 1960	May 31, 1962
9. University of Maryland, NsG 70-60, Dr. R. Kraus.	Investigation of phycophysiology in controlled environments.	216,000	36 months.	
10. Mississippi State University, NsG 80-60, Dr. R. Tischer.	Biochmeical study of mixed culture prototypes in a closed ecological system.	55,345	do.	
11. Colorado State University NsG 78-60, Dr. F. B. Salisbury.	(1) The use of pathogen-free plants in a microcosm; (2) effects of high intensity light on plant growth.	65,700	24 months.	
12. Southwest Research Institute, NASw-150, Mr. McKee.	Trace contaminants in enclosed systems.	40,000	12 months.	
13. University of Cincinnati, NsG 75060, Dr. B. Black-Schaeffer	Protection against acceleration by immersion during hypothermic suspended animation.	71,000	36 months.	
14. Columbia University, NsG 68-60, Dr. G. Nahas.	The buffering of carbon dioxide in the dog during prolonged hypercapnia.	14,500	12 months.	
15. Biological Warfare Laboratory, U.S. Army, NTF-88, Dr. R. Phillips.	Problems of space probe sterilization.	30,000	October 1959	
16. Stanford University, NsG81-60, Dr. J. Lederberg.	Cytochemical study of extraterrestial organisms.	40,000	12 months.	
17. Emory University, NASw-122, Dr. G. Bourne.	Investigation of the effects of space flight condition on live frogs and human and animal tissue.	2,185	Terminated.	

NASA LIFE SCIENCES COMMITTEE

The NASA Special Committee on the Life Sciences, chaired by Dr. W. Randolph Lovelace II, was organized in November 1958. In this group are representatives of the Army, Navy, and Air Force who provide liaison and advice for the biomedical aspects of Project Mercury.

Chairman: Dr. W. Randolph Lovelace II, director of the Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex. Members: Capt. Norman L. Barr (MC), Director, Astronautical Division, Navy Bureau of Medicine and Surgery, Washington, D.C.; Lt. Comdr. John H. Ebersole (MC), medical officer, U.S.S. *Seawolf*, Fleet Post Office, New York, N.Y.; Brig. Gen. Don D. Flickinger (MC), Assistant for Bioastronautics, Headquarters, Air Research and Development Command, Washington, D.C.; Col. Robert H. Holmes (MC), Armed Forces Institute of Pathology, Washington, D.C.; Dr. Wright H. Langham, Los Alamos Scientific Laboratory, University of California; Dr. Robert B. Livingston, Director of Basic Research in Mental Health and Neurological Diseases, National Institutes of Health, Bethesda, Md.; and Dr. Orr E. Reynolds, Director of Science, Office of the Director of Defense Research and Engineering, Washington, D.C. Boyd C. Myers II, NASA headquarters, is secretary of the Committee.

NASA BIOSCIENCE ADVISORY COMMITTEE

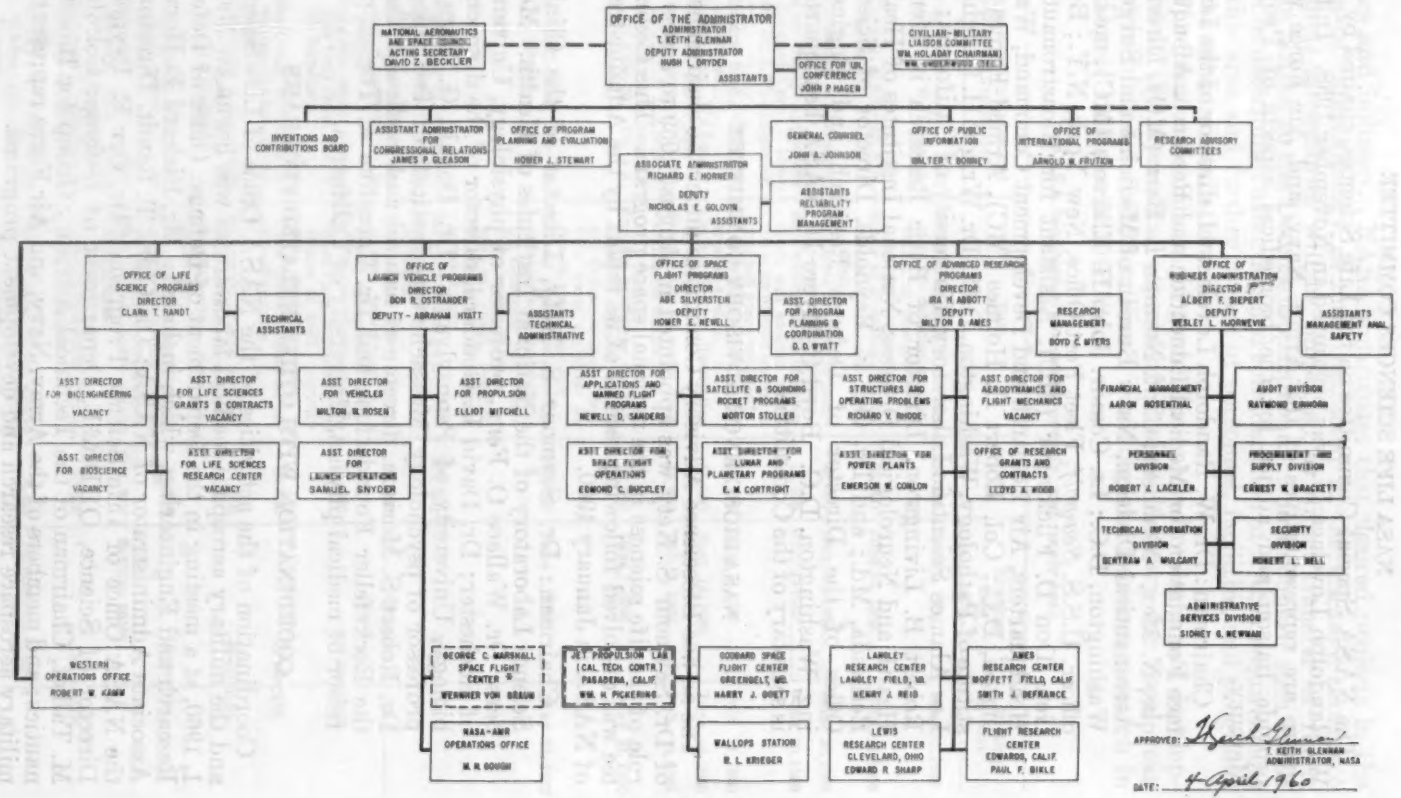
The ad hoc Bioscience Advisory Committee under the chairmanship of Dr. Seymour S. Kety was appointed in August 1959 to assess the role of the life sciences in the national space program. This Committee was dissolved following receipt of its report by the Administrator of NASA in January 1960.

Chairman: Dr. Seymour S. Kety, Director of the Clinical Science Laboratory of the National Institutes of Health. Members: Dr. Wallace O. Fenn, professor of physiology, University of Rochester; Dr. David R. Goddard, director of the division of biology, University of Pennsylvania; Dr. Donald G. Marquis, professor of psychology, Massachusetts Institute of Technology; Dr. Robert S. Morison, director of natural and medical sciences, the Rockefeller Foundation; and Dr. Cornelius A. Tobias, professor of medical physics, University of California.

COORDINATION WITH OTHER RELATED PROGRAMS

Coordination of the activities of the NASA Office of Life Sciences and the military aerospace medical laboratories was begun on March 1, 1960, at a meeting in the Department of Defense, Office of Defense Research and Engineering, which included: Mr. Richard E. Horner, Associate Administrator of NASA; Dr. Clark T. Randt, Director of the NASA Office of Life Science Programs; Dr. Orr E. Reynolds, Director of Science, ODDR&E, Department of Defense; Col. John M. Talbot, Chairman of the Technical Advisory Group for Bioastronautics; and members of the Army, Navy, and Air Force representing military aerospace research and development programs.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



* TRANSFER FROM U.S. ARMY PENDING. TO BE EFFECTIVE JULY 1, 1960.

APPROVED: T. Keith Glennan
T. KEITH GLENNAN
ADMINISTRATOR, NASA

DATE: 4 April 1960

SUPERSEDES CHART DATED FEBRUARY 7, 1960

The NASA Office of Life Science Programs plans to participate in the Biosciences Information Exchange, managed by the Smithsonian Institution. This service provides ready access to titles of current research proposals submitted to the Army, Navy, and Air Force, the U.S. Atomic Energy Commission, the Veterans' Administration, the U.S. Public Health Service, and the National Science Foundation.

2. NASA Replies to Committee Questions Concerning Its Office of Life Science Programs

National Aeronautics and Space Administration,
Washington, D.C., April 9, 1960.

Memorandum for the Senate Committee on Aeronautical and Space Sciences on Fiscal Year 1961 Authorization [From Pp. 36–40 of NASA Authorization Hearings]

"1. On March 1, 1960, NASA announced the establishment of an Office of Life Science Programs as the fifth major office of NASA and the appointment of Clark T. Randt, M.D., as its Director.

"Would you please tell the committee of some of the background that served as a basis for the establishment of this new Office?"

In accord with the mandate given the National Aeronautics and Space Administration in the Space Act of 1958, that "activities in space should be devoted to peaceful purposes for the benefit of all mankind," it is appropriate that the study of life processes in this new environment should constitute a significant part of the total effort.

Manned space flight and exploration are conceived to utilize man's unique capabilities for selecting and making a wide variety of unprogramed observations, for his ability to react intelligently to unanticipated situations, and for his resourcefulness and manual skill in servicing the complicated mechanisms of space vehicles in flight. These are indispensable contributions to the successful execution of space missions and to obtaining maximal scientific information not only related to biological problems but to the physical sciences as well.

The lead time for necessary advances in biotechnology which include man-machine integration, definition of tolerance of combined environmental stresses, development of life-support systems, and provision of adequate protective and escape devices requires a continuing vigorous effort.

Research designed to acquire basic medical and behavioral information relevant to meeting the physiological and psychological needs for long-term existence and effectiveness in stressful, artificial environments will necessitate augmentation of investigations in metabolism, respiratory physiology, cardiovascular physiology, neurophysiology, and psychology.

Basic biologic studies concerning the effects of space environments on living organisms and the search for extraterrestrial life anticipate investigation of molecular control

of cellular activity and of comparative biology on the broadest possible scale. Exposure of living cells and tissues to a broad range of ionizing radiation, weightlessness, low pressures, extremes of temperature, and unusual compositions of remote planetary atmospheres and surfaces opens a new window for observation of hitherto unexplained biologic phenomena. This research will bear upon such basic problems as the origin of life and the genetic mechanisms of evolution which will undoubtedly contribute to a better understanding of the fundamental laws of nature. Although these studies will be an outgrowth of continuing ground-based investigations, the space environment provides a new laboratory which cannot be duplicated on earth.

Recognition of these objectives gave rise to the appointment of the Bioscience Advisory Committee by NASA Administrator T. Keith Glennan in July 1959. The membership of this Committee was selected on the basis of the generally recognized stature of the individuals rather than prior interest in the national space program. It was chaired by Dr. Seymour S. Kety, Director of the Clinical Science Laboratory of the National Institutes of Health, and included Dr. Wallace O. Fenn, professor of physiology, University of Rochester; Dr. David R. Goddard, director of the Division of Biology, University of Pennsylvania; Dr. Donald G. Marquis, professor of psychology, Massachusetts Institute of Technology; Dr. Robert S. Morison, director of natural and medical sciences, the Rockefeller Foundation; and Dr. Cornelius A. Tobias, professor of medical physics, University of California.

The Bioscience Advisory Committee was apprised of aerospace medical facilities, programs, and personnel by 17 representatives of the Army, Navy, and Air Force, who comprehensively covered activities in this area. Representatives of industry and universities also provided background information for the Committee. Their report was submitted to Dr. Glennan on January 25, 1960, and its contents are now available to all those who are interested in this phase of the space program. This document reflects the considered opinion of six eminent individuals regarding the role of biology, medicine, and psychology in the NASA program. The recommendations have provided overall guide lines for the Office of Life Science Programs, which will be useful in further planning and development of the life science programs.

The Committee was well aware of the excellent contributions being made by the military aviation medical laboratories and the desirability of avoiding unnecessary duplication in this area. Important as the aviation medical contributions have been and will continue to be, additional opportunities in biology, medicine, and psychology are being presented in these fields related to the expanding space effort on a long-range basis. It is the purpose of the NASA Office of Life Science Programs to augment the outstanding work of

the military aerospace laboratories in order to provide basic contributions in space exploration.

Manned space exploration brings to the fore new problems which are essentially different and of another order of magnitude than those of conventional high altitude-high speed flight. The effects of ionizing radiation, weightlessness, and long-duration existence in an isolated, confining, artificial environment will require further mobilization of the talents of those who can contribute in the medical schools, industry, and other Government agencies as well as in the military services. To the greatest practicable extent, it is the intention of NASA to utilize the personnel and facilities of groups qualified by training and experience to contribute in these areas of research.

Basic biologic studies of the effects of space and other planetary environments on plant and animal life, as well as the search for extraterrestrial living organisms, are very promising sources of important scientific information. These studies represent a penetration into fields of research in addition to those which have been or would be explored in depth by the military services in satisfaction of a military requirement. Here again, however, contributions will be sought from qualified groups of professional men wherever they may be found.

In order to attract and productively utilize the talents of individuals with outstanding scientific potential who will form a small but high-quality nucleus of capability for leadership and integration of a national program, it is essential that an inhouse facility be developed. Although it is anticipated that the major portion of the NASA life science programs will be conducted through grants and contracts with universities, industry, and the military services, individuals of sufficient stature and a full-time interest will be indispensable in establishing and maintaining an appropriate degree of active participation with the physical scientists and engineers in the other operating divisions of NASA. A new facility in which this personnel complement will productively pursue their relevant interests will concentrate on the programing and development of biological experiments in space, medical and behavioral sciences, and basic biological research. This emphasis will assure no conflict of interest with the existing Aerospace Medical Laboratory's outstanding competence in biotechnology.

The NASA Office of Life Science Programs has already established liaison with the military efforts in this field through the Office of Defense Research and Engineering in the Department of Defense. Triservice representation in bioastronautics has been brought together in this Office under the Director of Science for joint consideration of future plans and transfer of funds, when necessary, to directly support appropriate proposals from the Army, Navy, and Air Force.

The NASA Office of Life Science Programs has been established to provide a focal point for activities in this area on

a national and international scale. It is the well-defined purpose of the Office to augment desired current programs and to supply the impetus for further life sciences contributions in space exploration.

"2. What specifically are NASA's future plans for its new Office of Life Science Programs in terms of staff size, budget amounts, and programs to be undertaken directly or sponsored?"

In fiscal year 1961, the Office of Life Science Programs anticipates a total personnel complement of 32, of whom 18 will be professional staff members. It is planned to conduct the program at a $5 million level.

The Office of Life Science Programs will be concerned with studies and detailed planning of the biomedical aspects of future manned space flight missions. A program of biological experiments in the upper atmosphere and space will be started. Funding of $3 million is anticipated for these efforts. A grant and contract program in support of these projects will be administered with the $2 million allocated for NASA sponsorship of bioscience research, as shown on page 146 of the authorization justification book. A Life Sciences Research Center for Flight Medicine and Biology, Space Medical and Behavioral Sciences, and Space Biology will be planned. It is not anticipated that this proposed facility will duplicate the biotechnological capability now present in the military service laboratories.

"3. On page 144 of the NASA authorization request justification book it is noted that the amount being requested for research grants and contracts in fiscal year 1961 is $10 million.

"How much of this amount will be devoted to research grants and contracts in bioscience, which is one of the categories that will be included in the program, as is indicated on page 145 of the book?"

Of the $10 million requested for NASA research grants and contracts, $2 million will be allocated for NASA sponsorship of bioscience research, as shown on page 146, and explained under question 2.

"4. In testimony before the House Committee on Science and Astronautics on March 9, 1960, Dr. Dryden said with reference to NASA use of military biomedical facilities: '* * * we are going to continue to use the service laboratories. The estimate is that three-quarters of our effort in this field will always be in the universities and service laboratories.'

"Would you please indicate to the committee how much, if any, of such funds in NASA's authorization request for fiscal year 1961 will be transferred to the Department of Defense for NASA work performed in service biomedical laboratories on a reimbursable basis?"

The amount to be transferred to the Department of Defense for NASA work performed in service biomedical laboratories is anticipated to be a significant fraction of the total

funding of the Office of Life Science Programs. A specific amount will require more detailed consideration of NASA requirements in this area and further review of personnel, facilities, and programs now present in the service installations.

"5. On page 5 of the report of the NASA Bioscience Advisory Committee, the so-called Kety report which served as the basis for NASA establishing an Office of Life Science Programs, the following statement is made: 'Supporting medical research and development in applied medicine and biology is being carried out in existing military aviation medicine facilities. Among 40 service biomedical laboratories 15 have noteworthy bioastronautics capabilities. The cost of these facilities is roughly estimated to be about $80 million. The 1960 Department of Defense budget for life sciences research and development is $47 million, including approximately $10 million for bioastronautics.' Does NASA plan to neglect or make use of these existing military facilities in its future long-range life sciences programs? How will this be done?"

The NASA intends to make use of the existing military facilities in its future long-range life sciences programs by direct transfer of funds in support of appropriate projects. The means for coordinating such activity was initiated at a meeting in the Office of the Director of Defense Research and Engineering of the Department of Defense on March 1, 1960. Mr. Richard E. Horner, Associate Administrator of NASA, and Dr. Clark T. Randt, Director of the NASA Office of Life Science Programs met with Dr. Orr E. Reynolds, Director of Science, Col. John M. Talbot, Chairman of the Technical Advisory Group for Bioastronautics, and members from the Army, Navy, and Air Force, representing the Department of Defense.

"6. NASA has frequently acknowledged publicly the valuable assistance the military biomedical facilities and personnel are giving in support of Project Mercury.

"(*a*) What proportion of Project Mercury's biomedical requirements are being supplied by the Defense Department?

"(*b*) Would the undertaking of Project Mercury have been possible without biomedical support by the military?

"(*c*) Has the Defense Department been reimbursed for the substantial facilities and personnel it has committed to Project Mercury, except for travel expenses and other minor costs. What major reimbursements have been made?"

(*a*) Almost all of the biomedical requirements of Project Mercury have been supplied by the Department of Defense. This assistance has been in the form of direct assignment of military personnel to NASA's Space Task Group and in making available facilities and other personnel for consultation and support. Typical facilities include the Navy centrifuge at Johnsville, Pa., and the Air Force facilities for nutrition, biophysics, and physiology at the Wright Air Development Division; the high-speed track and vivarium at the Aero-

medical Field Laboratory at Holloman Air Force Base, and the facilities at the Aero-space Medical Laboratory at Brooks Air Force Base.

In addition to the DOD-furnished equipment, other Mercury biomedical requirements are being supplied by NASA and its contractors. Specific examples include all the biomedical equipment within the Mercury capsule and at Mercury ground network stations.

(*b*) The undertaking of Project Mercury would have been substantially more costly and its operation may possibly have been delayed without biomedical support by the military services.

(*c*) The Department of Defense has been reimbursed for special equipment at the various military biomedical laboratories, for travel expenses, and for the salaries of medical personnel detailed to work directly within the NASA organization. Major reimbursements to the military include $25,000 to the Navy for pressure suits and $75,000 to the Air Force for support of the Mercury animal-training program.

"7. If in the future the military biomedical programs commit substantial proportions of personnel and facilities to NASA without adequate reimbursement for such assistance, do you feel that the Defense Department should be able to justify the existence of its biomedical facilities in part on such work that it performs for NASA?"

It is the intent of NASA and the Department of Defense to coordinate the support of much of the work that will be mutually useful; however, NASA will reimburse the Department of Defense for those programs carried out in the military biomedical laboratories which are specifically for NASA programs. Therefore, the need to justify the existence of military biomedical facilities on the basis of work performed for NASA should not arise.

"8. In fiscal year 1959, the National Science Foundation's annual obligation in support of basic research in the biological and medical sciences was about $20 million, and about $3 million for research facilities in the biological and medical sciences. Additional millions were spent through grant and fellowship programs. Other Government agencies spend substantial amounts every year in this very worthwhile area.

"One of the recommendations of the Kety report, the report of NASA's Bioscience Advisory Committee, was the following:

> "'That the Office of Life Science Programs assume proper responsibility for education and training in the space-oriented life sciences through postgraduate fellowships, training grants to institutions, and short-term visiting scientist appointments to be integrated with other NASA efforts in this area.'

"In view of the extensive programs already being carried out by Government agencies in this area, what specific plans does NASA have for the establishment of sound mecha-

nisms for coordination with other Government agencies having related programs of support involving grants, fellowships, and basic research, so that research results can be made known and utilized to the maximum extent possible?"

Planning for coordination of life science research and training programs is recognized as being highly desirable. As a first step, the NASA Office of Life Sciences will participate in the Bioscience Information Exchange which now provides service to the Army, Navy, and Air Force, the U.S. Atomic Energy Commission, the Veterans' Administration, the U.S. Public Health Service, and the National Science Foundation.

NASA recognizes a unique role in providing educational opportunities for life scientists as well as physical scientists in space exploration as well as the need to stimulate interest and accomplishment in studies of this newly opened environment by scientists now concerned in related fields of endeavor.

"9. What coordinating groups now exist and what groups are planned for the future to insure that NASA coordinates the operations of its Office of Life Science Programs with related programs in governmental and nongovernmental organizations?"

Except for the previously mentioned coordinating Technical Advisory Group for Bioastronautics in the Department of Defense, other liaison groups are now in the planning stage.

3. Report of National Aeronautics and Space Administration Bioscience Advisory Committee, January 25, 1960

* * * * * * *

(A Bioscience Advisory Committee was appointed by NASA Administrator T. Keith Glennan in August 1959 and given responsibility for (1) studying U.S. capability in space-oriented life science research and development, (2) outlining the scope of current and future problem areas in the space bioscience field, and (3) recommending the role NASA should play in future bioscience activity.

(Because of the significance of the report of the NASA Bioscience Advisory Committee, as well as the fact that it contains a basic source of information about NASA's concept of its future activities in the life sciences, it is reprinted in its entirety as follows through p. 58.)

* * * * * * *

Wallace O. Fenn, Ph. D.
David R. Goddard, Ph. D.
Seymour S. Kety, M.D., Chairman
Donald G. Marquis, Ph. D.
Robert S. Morison, M.D.
Clark T. Randt, M.D., Executive Secretary
Cornelius A. Tobias, Ph. D.

"Summary and Recommendations"

The role of the life sciences in the National Aeronautics and Space Administration program was evaluated by the Bioscience Advisory Committee at the request of the Administrator.

The objectives of space research in the life sciences are twofold: (1) Investigation of the effects of extraterrestrial environments on living organisms, including the search for extraterrestrial life; (2) scientific and technologic advances related to manned space flight and exploration.

The same reasons which prompted the establishment of NASA and gave it responsibility for all space research and development devoted to peaceful purposes require that NASA assume responsibility for leadership, coordination, and operation of the biomedical aspects of the national space program.

Present and future needs were considered in three broad categories:

1. Basic biologic effects of extraterrestrial environments, with particular emphasis on those phenomena associated with weightlessness, ionizing radiation, and alterations in life rhythms or periodicity as well as the identification of complex organic or other molecules in planetary atmospheres and surfaces which might be precursors or evidence of extraterrestrial life.

2. Applied or technologic aspects of medicine and biology as they relate to manned space flight, including the effects of weightlessness on human performance, radiation hazards, tolerance of force stresses, and maintenance of life-sustaining artificial environments.

3. Medical and behavioral scientific problems concerned with more fundamental investigation of metabolism, nutrition, blood circulation, respiration, and the nervous system control of bodily functions and performance in space equivalent situations.

The Bioscience Advisory Committee makes the following recommendations:

1. That NASA establish an Office of Life Sciences having the responsibility and authority for planning, organizing, and operating a life sciences program including intramural and extramural research, development, and training.

2. That a Director of Life Sciences be appointed who is directly responsible to the Administrator of NASA in the same manner and at the same directional level as the other program directors.

3. That the internal organization of the Office of Life Sciences include Assistant Directors for Basic Biology, Applied Medicine and Biology, Medical and Behavioral Sciences, and the life sciences extramural program.

4. That an intramural life sciences program and facility be established with three sections:

   (*a*) Basic biology.
   (*b*) Applied medicine and biology.
   (*c*) Medical and behavioral sciences.

5. That the Director of Life Sciences recommend advisory committees made up of consultants outside of NASA to be appointed by the Administrator.

6. That maximum integration of the personnel and facilities applicable to the space-oriented life sciences in the military services and

other Government agencies be arranged in the most appropriate manner indicated by the nature and extent of the specific problem at hand.

7. That the Office of Life Sciences assume proper responsibility for education and training in the space-oriented life sciences through postgraduate fellowships, training grants to institutions, and short-term visiting scientist appointments to be integrated with other NASA efforts in this area.

8. That the NASA life sciences program place special emphasis on the free exchange of scientific findings, information, and criticism among all scientists.

9. That security regulations be exercised with great caution and limited to matters in which national security is clearly involved.

10. That the NASA life sciences facilities be considered a public trust in implementing national and international cooperative efforts.

"I. The Role of the Life Sciences in the National Space Effort"

The Congress of the United States has given to the National Aeronautics and Space Administration the responsibility for all space research and development devoted to peaceful purposes. NASA has begun the fulfillment of this responsibility with an emphasis on the physical and engineering sciences which occupy a fundamental position by virtue of their pertinence to the design, launching and control of all vehicles, whatever their ultimate scientific purpose. With this aspect of the total program well under way, attention is properly being directed to other disciplines which, though dependent on the engineering sciences, will in turn give scientific meaning to the national effort. The biological, medical, and behavioral sciences are among these disciplines. The Bioscience Advisory Committee has been appointed to aid in representing them adequately within the NASA program.

The reasons which prompted the Congress to create NASA as a civilian space agency and to give it responsibility for achieving the peaceful purpose of the national effort in space argue equally strongly for the creation in NASA of a strong division of life sciences. As set forth below, two major areas represent the role of the biological sciences in the national space effort and should form the core of the proposed program in the life sciences of NASA. These are the fundamental biological questions relative to extraterrestrial environments and the scientific and technologic aspects of manned space flight.

It is altogether fitting that these matters, both of which involve man's curiosity about himself and his environment in their broadest and most fundamental sense, should be placed in the hands of an agency broadly representative of society as a whole. The military agencies which have so soundly laid the groundwork for much of existing space technology must properly give primary attention to the development of weapons systems and the national defense. Although the military effort in astronautics should not be arbitrarily restricted by narrow definitions of military relevance, the broader implications of extraterrestrial exploration demand the attention of an organization unhampered by such predetermined objectives.

Space exploration has captured the imagination of men the world over to an extent which was not, perhaps, anticipated. These activi-

ties have become representative of technological superiority among nations. The United States must maintain its international role as a strong and self-confident but basically peaceful and benevolent power. This requires that the first of her citizens who enter space do so as representatives of the scientific aspirations of all men and not as a symbol of military strength.

The basic study of extraterrestrial environments is ultimately likely to be most productive in furthering an understanding of the fundamental laws of nature. Among the most perplexing questions which have challenged men's minds are the nature and origin of life and the possibility of its presence elsewhere in the universe than on the Earth alone. For the first time in history, partial answers to these questions are within reach. Limited knowledge acquired over the past century concerning atmospheric and climatic conditions on other planets, the topographical and seasonal variety in color of the surface of Mars, the spectroscopic similarities between scattered sunlight from portions of that planet and those demonstrable from algae and lichens on Earth have suggested the presence of extraterrestrial environments suitable for life and permitted the formulation of hypotheses for the existence there of some forms of life at present or in the past. These hypotheses may, within the foreseeable future, be tested, at first indirectly by astronomical observations made beyond the interference of the Earth's atmosphere and by samplings taken mechanically from various celestial bodies, and finally, by direct human exploration. The discovery of extraterrestrial life and a description of its various forms, knowledge of the presence and types of complex molecules based on carbon or other elements, or conversely, the absence of living organisms or of their traces in environments conducive to life will have important implications toward an ultimate understanding of biological phenomena.

These studies will not be complete until the scientist himself is able to make meticulous investigations on the spot. This is true, not only for the biological, but, also, for many other physsical, chemical, and geological problems which are involved. Although significant engineering achievements in automation, sensing, recording, programming and telemetering have been realized and considerable future development is in prospect, the indispensability of the human observer in much of space exploration is well established. Man's versatility and selectivity, his ability to perceive the significance of unexpected and unprogramed findings or to react intelligently to unanticipated situations have not been simulated by any combination of physical devices, however complex, which have been developed or are even contemplated. Human intelligence and manual skill in servicing the complicated mechanisms of space vehicles or repairing breakdowns in flight are not readily dispensed with or replaced. When along with these attributes are considered his weight of 70 kilograms, his total resting power requirements of 100 watts, his ability to function for years without maintenance or breakdown, then even the most elaborate provisions for his sustenance, welfare, and safety are amply justified simply in terms of engineering efficiency. A national program in space science which does not recognize the essentiality of the human observer and does not plan to utilize him most effectively may wait

indefinitely for the automatic devices to replace him or be limited to incomplete and opportunistic observations.

Putting a man into space, especially if he is to stay for long periods, is a task which involves considerable attention and effort from a wide variety of biological, psychological, and medical specialties. It will require careful planning and extensive basic and developmental research. Together with the effort in astrobiology it should constitute a substantial part of the total space research and development enterprise.

It comes as no surprise to find that the early stages of space research have been primarily concerned with engineering matters. To many responsible people it seems premature if not actually presumptuous to think about what man will do in space until we are sure that we can actually put him there. But the validity of even the earliest of engineering decisions must be continually appraised in terms of their capacity to maintain man comfortably and effectively in space and increase his knowledge of its properties. Failure to meet the numerous and often subtle physiological and psychological needs of the human organism, or premature decisions to send man off into an unknown universe can have disastrous effects not only on the individuals concerned, but on the Nation's political and moral position in the eyes of the world. The scientific objectives of the program and especially the determination of the nature of extraterrestrial life may be forever rendered impossible if vehicles containing complex organic molecules are carelessly allowed to contaminate celestial bodies before science has had a chance to study the original conditions. Nor can we simply ignore the perhaps remote possibility that infective organisms brought back from space to Earth may cause human disease or destroy food crops essential to human life. How is the necessary biological wisdom to be brought to bear in planning the space effort?

As pointed out later in this report, the Nation's best scientific brains are already organized in the form of advisory committees to study and consult on every detail of the space problem. However, such outside bodies, no matter how soundly constituted, cannot have effective impact on day-to-day decisions within the space agency unless the agency itself is provided with a sensitive and powerful administrative mechanism for receiving the advice and translating it into the energy of decision.

To implement this program in the life sciences, appropriate in size and importance to its responsibilities, it is essential to have in NASA a Director of Life Sciences reporting directly to the Administrator of NASA so that the biomedical interests and skills will have adequate representation in important decisions. The director of the life sciences program, therefore, must have broad biological training and interests. He must be able to understand the physicists and engineers as well as have the ability to present biomedical aspects of combined problem areas effectively to his colleagues so that he can have appropriate influence on comprehensive policies and decisions.

These reasons compel the committee to emphasize that the NASA life sciences program requires and deserves strong financial support and adequate administrative representation.

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II

"A. PRESENT STATUS OF LIFE SCIENCES ACTIVITIES"

The present status of activities in the space-oriented life sciences may be considered under the general headings of: Basic biology; medical and behavioral sciences; and applied medicine and biology. Current activities are predominantly in the third category which includes research and development in manned space flight technology for five major programs:

(*a*) The NASA-Air Force-Navy X–15 rocket-powered research aircraft project begun in 1954 utilizes a "near space" vehicle expected to reach altitudes of about 100 miles. The first powered flight to approximately 60,000 feet has recently been accomplished.

(*b*) Project Mercury was organized by NASA in October 1958 to (1) place a manned space capsule in orbital flight around the earth; (2) investigate man's reactions and capabilities in this environment; and (3) recover the capsule and pilot safely. The NASA Space Task Group responsible for Project Mercury includes military medical personnel and pilots on temporary duty with NASA at Langley Research Center.

(*c*) The Air Force Discoverer Project is concerned with recoverable polar orbiting Earth satellites, one of which contained mice, and later, will include monkeys to test life support systems and the effects of space flight on animals as well as testing techniques for recovery of the capsule and occupants.

(*d*) Contracts have been let recently by the Air Force to implement the Dyna-Soar program for development of a manned maneuverable boost glide vehicle to explore hypersonic performance up to orbital speeds and to investigate the accompanying reentry problems.

(*e*) Supporting medical research and development in applied medicine and biology is being carried out in existing military aviation medical facilities. Among 40 service biomedical laboratories, 15 have noteworthy bioastronautics capabilities. The cost of these facilities is roughly estimated to be about $80 million. The 1960 Department of Defense budget for life sciences research and development is $47 million, including approximately $10 million for bioastronautics. The NASA research centers are continuing studies utilizing fixed base flight simulators and variable stability aircraft to further delineate man's function in aircraft operating problems. Several dynamic flight simulators capable of reproducing some portions of space flight mission profiles are now being developed at the Langley and Ames Research Centers. Biomedical participation in these projects is, at present, insufficient. The larger aircraft companies are investing several million dollars in space flight technology this year. The latter effort is mainly concerned with bioengineering and technical development.

In addition to the considerable amount of work specifically designed to solve recognized biotechnical problems connected with space flight, there is an even larger amount of work which although nominally carried on for other purposes contributes to the field of space medical and behavioral science. One may cite, for example, those studies now being carried out in universities, medical schools, the National Insti-

tutes of Health and under the auspices of the Atomic Energy Commission dealing with physical stress, including ionizing radiation; environmental physiology; and behavior.

In contrast to the large amount of work bearing on practical problems of space medicine, space-oriented basic biological research has received little attention to date. A relatively small group of university biochemists and biophysicists have recognized that space exploration offers a unique opportunity to study the origin of life and the effects of extraterrestrial environments on living organisms and they have tried to formulate some definite plans for appropriate research.

"B. ADVISORY COMMITTEES FOR SPACE-ORIENTED LIFE SCIENCES"

Senior representatives of the Army, Navy, and Air Force recommended late in 1957 that the National Academy of Sciences provide, through the National Research Council, an advisory committee in the life sciences covering all biological and psychological fields of interest in the space environment. This led to the establishment of the Armed Forces-National Research Council Committee on Bio-Astronautics under the Division of Medical Sciences of the National Academy of Sciences. Dr. Otto Schmitt was appointed chairman. This group includes 180 individuals from civilian institutions, the military services, and Government agencies. The Committee on Bio-Astronautics is more comprehensively represented in the man-in-space problem areas although there is considerable basic biologic representation as well.

Dr. W. Randolph Lovelace II, was appointed chairman of the NASA Special Committee on the Life Sciences by Dr. Glennan in October 1958. Its role has been essentially that of an advisory panel for Project Mercury.

The Space Science Board of the National Academy of Sciences was established in 1958. Of the 12 committees of this Board, only 1 has particular relevance in the biological area, the Committee on Psychological and Biological Research. Dr. H. K. Hartline is chairman of this Committee which has expressed general interest in the man-in-space program but has found its principal concern in basic biology, particularly the areas related to problems of extraterrestrial contamination and the detection of extraterrestrial life. To focus attention of biologists on these problems, Dr. Hartline's committee joined with the long-range planning committee of the Space Science Board to set up two additional groups designated EASTEX and WESTEX, chaired by Dr. Bruno Rossi and Dr. Joshua Lederberg, respectively. The names of these latter two committees derive from a committee (CETEX), established by the International Council of Scientific Unions to explore problems of extraterrestrial contamination.

The functions of this latter organization have now been absorbed by the Committee on Space Research (COSPAR) within the International Council of Scientific Unions.

Liaison between these planning and advisory groups has been established by appointing a number of individuals as members of two or more groups. The effectiveness of these committees has been limited by the lack of an overall operational life sciences program which

would implement the suggestions of the committees to make the best use of the unprecedented opportunities provided by space exploration.

"III. Present Needs"

(a) *Basic biology*

In order to attain overall objectives in the space-oriented life sciences, an imaginative and long-range program in the broad field of astrobiology is required. This should include the further development of hypotheses relating to the origin of complex organic molecules and of living matter, further observation, both from the earth and from artificial satellites, of the surface environments of neighboring celestial bodies, studies on the adaptive effects of simulated extraterrestrial environments on various forms of life in successive generations, the study of meteorites and "cosmic dust," and, eventually, the exploration by man of lunar and planetary surfaces for complex molecules, organic substances, or evidence of forms of life. Indeed, one of the most important justifications for an extensive effort in space exploration is the promise which it offers of substantial advance in our understanding of these basic problems in biology and astrophysics. From this point of view the biomedical and engineering task of achieving human space travel is but a means to that end.

With this in mind, a program should be initiated shortly and projected indefinitely into the future in which a significant number of payloads would be dedicated primarily to biomedical purposes. These should be engineered from their inception with biological purposes in mind as opposed to the present opportunistic "space available"—"noninterference" provision. The payloads should be engineered to biological specifications. The trajectory should be carefully chosen for each experiment with regard to specific biological objectives. All worthy experimental investigations proposed by members of the scientific community should be given consideration for available biomedical payloads.

(b) *Applied medicine and biology*

The present program in this area appears to be centered on Project Mercury, the aim of which is to put a man safely into space for several orbital flights about the Earth before return and recovery. There is need that this worthwhile phase of space research and development be adequately supported, but also that it be integrated with proper perspective into a long-range biomedical program with respect to its scientific objectives, its timing, and its budgeting. For reasons which have been outlined earlier in this report, the Committee believes that human observers, properly trained in the appropriate scientific disciplines, are indispensable components of space research. Project Mercury, by marshaling a wealth of engineering and biomedical effort on one step toward that goal, is fulfilling an important and necessary first objective. This project also has certain values in terms of technical and scientific achievement and prestige on a national and international scale. It is even more important that the thought and effort which have been devoted to questions of human safety be continued and emphasized; that the peaceful scientific objectives be clearly delineated, augmented, and stressed; that attention be given to increasing the scientific information to be obtained from

the project; and that these data be made widely available in order that this great effort be perceived as a sober scientific mission rather than a tour de force.

Problems relevant to manned space flight which require and are presently receiving attention are many in number. Several major groups are discussed below, and a summary of the various problem areas in various disciplines which are relevant to space bioscience is given in table I.

1. *Weightlessness.*—The effect of weightlessness is an unusual one in that its simulation for prolonged periods can only be achieved in satellites or spaceships. A number of consequences are possible. Certain physical properties of matter in the solid, liquid, and vapor states may be significantly affected. The method of heat convection and diffusion may be radically altered. It is possible that intracellular events could occur in different time sequence. Plants and other living forms, which normally grow against gravity, may take on peculiar morphological characteristics. Many physiological variables may undergo change; for example, neural and cardiac function, circulation, and metabolism. The sensory basis for normal bodily orientation will be profoundly altered. The effects of gravity-free states and various low-gravity conditions should be investigated in a variety of living forms in satellites on both short and long flights.

2. *Force stresses.*—In space flight, many mechanical factors and forces occur that are encountered only in small measure at ground level. Great forces pin down the astronaut during initial acceleration and reentry as well as during emergency escape. Spinning, tumbling, vibration, and noise present environmental stresses which require further study. The Armed Forces laboratories have made significant advances in studies of the physiological effects of such forces, but further information could be provided by new centrifuges and other simulators with more degrees of freedom of motion and combinations of stresses.

3. *Radiation.*—Radiation in space presents a great challenge to physical as well as biological scientists. There are intense and not fully explored radiation belts in the magnetic field surrounding the Earth. In addition, many particles arrive on the surface of the Earth from space and from the Sun. Some of these have not as yet been fully explored, and only part of the radiation spectrum has been reproduced at ground level in accelerators to date. Among the cosmic radiations, there are large streams of the nuclei of light and heavy atoms which can produce untoward biological effects. Their study, utilizing the tools of radiobiology, will provide more information about living processes. Such studies should include additional physical measurements and biological assay of the radiations in space, their simulation at ground level, and, finally, direct experiments on living material of all types in statellites to provide quantitative empirical information on various biological effects not only on immediate metabolism and function but also on survival, longevity, carcinogenesis, and mutations.

4. *Closed environment.*—If man is to explore space, he will need to live in the closed and isolated environments of the space vehicles and stations. Even after the first landings on planets, he will probably have to be constantly maintained in an artificial environ-

ment compatible with functional effectiveness as well as survival. Storage and supply of oxygen, water, and nutrients and the disposal of carbon dioxide and wastes are problems to which a number of partially satisfactory solutions have already been obtained. For long-term missions, biological or chemical systems for regenerating the essential requirements of human metabolism from its products are presently in the early stages of development. Certain psychological concomitants of confinement, isolation, and diminution of sensory input are of far-reaching consequences and their investigation is relatively new.

Because many of these problems are also encountered in present military operations most of the recent and current progress in these areas has come from the armed services.

5. *Changes in ambient time cycles.*—On Earth, living organisms are geared to a 24-hour cycle. It is possible to detect diurnal periodicity in most biological variables. Spaceships or planetary stations will provide entirely different periods to which the organism will adjust with varying degrees of success. The problems of physiological and psychological adaptation are broad ones which can be studied in terrestrial as well as extraterrestrial laboratories.

6. *Toxicity and contamination.*—Biologists and medical scientists are interested in contamination carried by us into space, in the form of viruses and micro-organisms, as radioactive matter when reactor or nuclear explosions occur, or in the form of chemical compounds which might profoundly modify our own atmosphere to the extent that they become health hazards. The polonium battery and fluorine-containing rocket fuels are examples of gravely toxic materials. NASA should maintain a competent staff to deal with such health hazards, and future engineering planning should be subject to critical review and necessary limitations for public health protection.

In closed space vehicles, atmospheric contaminants ordinarily of negligible importance may achieve toxic concentrations and require special attention.

(*c*) *Basic medical and behavioral sciences*

Solutions to immediate, practical problems such as those exemplified above depend upon a broad base of information obtained in more fundamental aspects of medicine and behavioral sciences. Although much of that information is being accumulated in the course of the extensive research in these fields in universities and medical institutions, the needs of space science are especially dependent upon a number of specific areas, examples of which may be outlined as follows:

1. Respiratory physiology—including the control mechanics, and physical chemistry of mammalian respiration; gaseous diffusion and exchange; effects of alterations in ambient conditions of pressure and temperature.

2. Circulatory physiology—including circulatory reflexes, the control of the circulation, its response to gravitational and accelerative stress, to alterations in oxygen and carbon dioxide tensions and temperature change.

3. Metabolism—including energetics, nutrition, hibernation, digestion, excretion.

4. Neurophysiology—including postural and righting reflexes, physiology of vision, audition, proprioception, and orientation;

central control of metabolism, temperature, endocrines, circulation, and respiration; circulation and metabolism of brain.

5. Behavioral science—including perception, motivation, and performance under stress, emotional stability, fatigue, social and sensory isolation, psychological assessment and training for special missions.

TABLE I.—*Problem areas in the life sciences*

Extraterrestrial life	Stress factors	Radiation	Closed environments
1. Interplanetary matter. 2. Planetary atmospheres. 3. Molecular composition on planets. 4. Unknown forms of life. 5. Extinct life. 6. Primordial life. 7. Planetary systems in the universe. 8. Terrestrial life on different planetary environments. 9. Biological cross contamination. 0. Chemical contamination.	1. Compression-decompression. 2. Acceleration. 3. Weightlessness. 4. Spin and tumbling. 5. Vibration-shock. 6. Noise. 7. Dust particles and meteorites. 8. Isolation, confinement, and fatigue. 9. Optimum mechanical integration of systems in manned satellite stations. 10. Methods of escape and communication.	1. Microwaves. 2. Infrared. 3. Visible. 4. Ultraviolet. 5. X-rays. 6. Van Allen belt. 7. Cosmic rays. 8. Nuclear power and propulsion devices.	1. Photosynthesis. 2. Chemical oxygen-carbon dioxide exchange. 3. Control of closed atmospheres. 4. Nutrition. 5. Temperature-pressure. 6. Clothing. 7. Water balance. 8. Waste products. 9. Toxicity. 10. Microbial flora. 11. Theoretical stability. 12. Energy balance. 13. Hibernation—suspended animation. 14. Psychological and physical support for well-being. 15. Communication. 16. Monitoring, warning and safety devices.

"IV. RECOMMENDATIONS FOR A NASA PROGRAM IN THE LIFE SCIENCES"

"A. ORGANIZATION OF THE OFFICE OF LIFE SCIENCES"

This Office should have the responsibility and authority for planning, organizing, and operating the life sciences program of NASA, including intramural and extramural research, development, and training. This Office would also advise and consult with the other divisions of NASA and with the Administrator in matters involving biology, medicine, and psychology. It should have the responsibility for safeguarding the welfare of human subjects and the public health, as well as definitive participation in those projects which might jeopardize satisfactory investigation of possible extraterrestrial life.

1. The Director of Life Sciences would be vested with the responsibility and authority of the Office of Life Sciences and should be responsible directly to the Administrator of NASA in the same manner and at the same directional level as the other program directors. The caliber of the incumbent is obviously of fundamental importance. He should be a man of high scientific stature, an able administrator with demonstrated capability in the selection and direction of staff. It is probable that the Director will be found among physicians who have had considerable experience in the basic medical sciences, although there are others who are not physicians who might have the requisite background.

2. The internal organization of the Office of Life Sciences: The Committee proposes that the Office be organized in four sections, each

with an Assistant Director responsible to the Director of Life Sciences.

(*a*) Section on Basic Biology.
(*b*) Section on Medical and Behavioral Sciences.
(*c*) Section on Applied Medicine and Biology.

The substantive nature of the program of each of these three sections is indicated under the respective heading in section III of this report, although considerable latitude in planning should be given to each Assistant Director.

(*d*) Section on Extramural Program.

This Section should be responsible for the administration and, in collaboration with the other Assistant Directors and the Director of Life Sciences, the planning of the extramural program.

3. Advisory committees: The Director of Life Sciences may desire an advisory committee made up of consultants outside the NASA, recommended by him and appointed by the Administrator. Such a committee would normally report to the Director of Life Sciencies or, on occasion, directly to the Administrator of the NASA.

The Assistant Directors of the four sections may well need advisory committees for their activities. These could be made up of NASA personnel plus outside consultants.

"B. INTRAMURAL PROGRAM OF THE NASA OFFICE OF LIFE SCIENCES"

For a number of cogent reasons, an intramural program in the life sciences of significant size, diversity, and excellence should be established by the NASA. It is urgent that this program be initiated without delay.

1. Objectives

The present research effort in this field within NASA appears to be concentrated upon a single specific goal, exemplified by Project Mercury, at the possible expense of broader, more remote, but fundamental aims. It is important that the biomedical aspects of the Project Mercury be placed squarely under the jurisdiction of the Office of Life Sciences and that it be coordinated with other aspects of the life sciences program. The remainder of the national space biomedical effort, as found in military, industrial, and academic laboratories, is sporadic and incidental to other primary interests or responsibilities. These efforts are, on the whole, of excellent quality and should be maintained and supported; there is need, however, in addition to these and coordinated with them, for a broad and thoughtfully planned biomedical program of research extending from the most fundamental aspects to their most practical applications. The nucleus of such a national undertaking should be the NASA intramural program in biology, medicine, and psychology.

The number of competent biological, medical, and psychological scientists motivated toward space research and skilled in its special problems and techniques is, at present, seriously limited. It is necessary to create a number of career opportunities in these fields on a long-term, full-time basis, and to increase the number of laboratories and facilities in which postgraduate training for such careers may be accomplished.

An important ingredient of a productive and creative research effort is the opportunity for interaction among scientists in all the relevant disciplines; between those whose interests are in the fundamental areas and those working in the applied aspects of the problem. The need for interaction has become essential in recent years as the result of the high degree of specialization which modern science and technology demands and the accelerating rate at which new knowledge is accumulating. The older formula for creativity which depended upon the accumulation by a single mind of all the information necessary to a new concept is becoming increasingly difficult to achieve; it may, partially at least, be replaced by the daily contact and collaboration among scientists within a single institute.

An active and distinguished research program in the biological, behavioral, and medical sciences within NASA should provide an atmosphere of knowledge and responsibility in which the national effort in these fields can best be planned, administered, and coordinated. It should be represented at the highest administrative levels within NASA and should participate in the planning and direction of the entire space program. Its members should be available for consultation and should be given appropriate responsibility and authority in all of NASA activities which involve biology, medicine, or psychology.

2. Scope of intramural life sciences facilities

To fulfill these objectives, the Committee recommends an intramural research program whose ultimate dimensions may be envisioned as follows:

(*a*) A broad central facility with laboratories ranging from the most basic biological, behavioral, and medical disciplines through their highly applied aspects. A site at Goddard Space Flight Center at Greenbelt, Md., or adjacent to the National Institutes of Health recommend themselves, each for somewhat different reasons. The latter would offer the advantages of the unsurpassed facilities of the National Library of Medicine and of interaction with basic and clinical medical, behavioral, and biological scientists at the National Institutes of Health, the adjacent Naval Medical Center, and the Walter Reed Army Medical Center and Armed Forces Institute of Pathology, which are only a few miles away. All of these opportunities would make the NIH site especially advantageous and attractive to scientists in the medical, biomedical, and behavioral fields. The Greenbelt site, on the other hand, would offer active interfaces both with the space sciences and space technologies and also with the basic biological sciences represented in the laboratories of the Department of Agriculture. This site has a further advantage in the potential for expansion as a national space center which the greater congestion and the different orientation of the NIH could not make possible. Further plans regarding the facility should be the responsibility of the Director of Life Sciences and his staff, who will make specific recommendations to the Administrator.

(*b*) A limited number of additional facilities situated at some of the present or future NASA installations and, possibly, an institute at one or two universities. Each of these accessory groups would be somewhat differently oriented depending on the special functions and

the variety of competences represented in their environs. Thus, an institute located at a university with an important biological tradition should be more heavily weighted toward basic astrobiology, while one situated where astronomy and physics were emphasized should reflect an orientation toward astrophysics. The groups to be incorporated into NASA installations, on the other hand, should be primarily representative of the technological and engineering aspects of biology and medicine. They would thus be in a position to utilize the unique facilities of these installations in the furtherance of astronautcal research and, conversely, this would insure that engineering development of space vehicles would be carried out with due regard for the requirements of future occupants.

The Committee is reluctant to stipulate the dimensions which these facilities should attain or to indicate more precisely their scientific complexion. It would suggest, however, that the directors would give prior consideration to high quality rather than quantity, realizing that excellence is not necessarily proportionate to size.

It would emphasize, however, that at least some of the peripheral units, as well as each of the three units of the central facility, be planned in terms of a minimum critical mass, defined as an adequate variety of disciplines and number of professional personnel and their necessary supporting staff and physical facilities to constitute a self-sufficient, mutually interacting, and sustaining unit. It is of interest that the varied experience of the Committee members converged on an estimate of 20 scientists and 30 to 35 supporting personnel as constituting such a minimal staff. An annual budget of $800,000, exclusive of permanent equipment but including overhead or reimbursement, would probably be required to support such a minimum unit, and a facility of 30,000 square feet, overall, to house it, based upon acceptable standards of biomedical research in other fields. This would indicate, therefore, an annual budget for the central facility of the order of $2.4 million and a total of 90,000 square feet.

Even where the program of a unit were oriented to one or another aspect of the field, as would be the case in the accessory laboratories, the scientific staff should be representative of numerous disciplines, basic as well as applied.

3. Development of the intramural program

The rate of growth toward an intramural program of the scope outlined above will perforce be limited by the total budget and the competitive needs of the parent agency. More important, perhaps, may be the limitation, self-imposed by the program's directors in recognition of the paucity of adequately trained personnel and the other national needs for such individuals, including the needs by the military departments for national defense and security and the needs of academic and other institutions for teaching and research.

The Committee recommends, therefore, that the development of the intramural program be deliberate and gradual with cooperative utilization of presently available manpower and facilities which are outside of NASA, and their judicious duplication or replacement by the intramural NASA program as those facilities become obsolete or overutilized and as the total resource of competent and motivated scientists is augmented by a training program which NASA itself will substantially support.

The immediate and most pressing need of the program is the appointment of a Director of Life Sciences and, on his recommendation, the Assistant Directors. (See Sec. IV–A: Organization.) It should be the responsibility of the Director and his Assistant Directors, in consultation with an advisory council, should one be appointed, to plan a national program for NASA in the life sciences, to determine its complexion, establish its philosophy, recruit its senior personnel, and guide its development.

The Committee recommends that the Director of Life Sciences and his staff in their initial planning select those segments of the national program which are currently being carried out by existing facilities in the military services, in universities and research institutes, and by industry, or which certain of these facilities are capable of carrying out in the immediate future. By appropriate contracts, transfer of funds, construction grants, or other mechanisms of support, participation of these existing facilities in a coordinated national program should be invited and made feasible.

At a very early date, the Director of Life Sciences and his staff should begin the planning, construction, and organization of the central and certain of the auxiliary facilities, concentrating on those areas of basic and applied science not adequately provided for in existing programs.

As major physical facilities utilized by the NASA biomedical program on a cooperative basis and of primary concern to that program (i.e., centrifuge and controlled environmental chambers) become obsolete or overutilized, or as completely new designs become necessary and feasible, these may be constructed by NASA within its intramural program and maintained as national and international facilities. This should not prevent the construction of similar facilities by other agencies where necessary to the execution of their respective responsibilities. Present cooperative arrangements are a fitting precedent for the continuance of the concept that these expensive facilities should be shared wherever possible both in cost and usage, but that the initiative and responsibility for the construction of any one of them should lie with the agency which has the greatest need.

"C. EXTRAMURAL PROGRAM OF THE NASA OFFICE OF LIFE SCIENCES"

Investigations in extraterrestrial biology and resolution of problems related to manned space flight provide an area for research and development necessitating many diversified contributions. An optimum rate of achievement will require further cooperation with other Government agencies. Important contributions are expected to come from scientists working in universities, research institutes, and industry. Thus a strong extramural program is an essential aspect of the activities of NASA in the life sciences (1) to mobilize the relevant research talent; (2) to obtain ideas, information, and participation essential to the activities of NASA from the best qualified available sources; (3) to generate among the scientific and industrial communities an awareness of the activities of NASA and to secure support of its programs.

1. Grants

NASA should set up a system of research grants for individual scientists or groups of scientists working in universities or nonprofit research institutes based on original research proposals and with appropriate means for their review and approval. Such grants should be for the support of basic or applied research in areas of interest to NASA. These areas of its interest should be broadly interpreted. Proposals from well qualified interdisciplinary groups should be encouraged.

2. Contracts

We believe that the NASA should enter into contracts with industrial corporations and governmental agencies for specific research needs, particularly in the field of technology, but also in fundamental research. Such research contracts are particularly favorable for the solution of short-term problems which might be inefficiently studied in an intramural program and which might require the hiring of specialized scientists or the building of particular equipment that would have no long-term value to the agency.

3. Timing

The Committee strongly recommends that the grant program and perhaps research contracts should be initiated so that money is available to the recipients at the earliest practicable date. The initiation of this program need not await the setting up of the permanent organization of the life sciences. The NASA may be able to borrow an experienced official from the U.S. Public Health Service, the Office of Naval Research, or the National Science Foundation to get this program underway. Alternately, the NASA could delegate the approval of such grants to the National Research Council-National Academy of Sciences. The sort of study section mechanism used by the U.S. Public Health Service could serve as an excellent model.

"D. RELATIONSHIP OF THE NASA OFFICE OF LIFE SCIENCES TO EXISTING PROGRAMS IN THE MILITARY SERVICES"

The effort to put living animals and men into space and to maintain them there for considerable periods of time requires the development of many new techniques for protection from unfamiliar stresses. The nature of these stresses is reviewed elsewhere in this report. Study of the physical, chemical, biological, and psychological stresses of space flight requires an extensive array of apparatus and a large staff of trained scientists and technicians. Additional facilities and close liaison with the physical scientists and engineers engaged in vehicle research and development are essential to provide proper life-support systems and protection for the passengers in this new form of transportation.

The existing capability for studies of this character is found almost entirely in the military services. Except for a few aircraft companies, civilian agencies have had little need to develop studies of high-altitude, high-speed flight, and NASA itself has so far concentrated almost entirely on the physical and engineering aspects of flight problems.

The military medical services, on the other hand, have been continuously engaged since the First World War in developing facilities and personnel for aeromedical studies. No attempt will be made here to draw up a list of the facilities now available. It is only necessary to note that, taken together, these installations provide a variety and quantity of controlled environment chambers, centrifuges, acceleration tracks, and other relevant apparatus which may not be equaled anywhere else in the world. The Committee was especially impressed with the quality of the personnel available for work in these laboratories and their enthusiastic dedication to the job. It is difficult to measure the existing capability in terms of money, but the investment in men and machines must represent at least $80 million and perhaps a good deal more. More important is the time which would be required to build similar installations or train comparable personnel for use elsewhere.

It appears that the military capability in aeromedicine is, at present, not fully utilized. The reasons for this are somewhat complicated and require at least brief exposition. In the first place, many of the biomedical problems of conventional high-altitude flight are now reasonably well solved. Furthermore, the military requirement for conventional aircraft is increasingly uncertain. Fewer such vehicles are planned for the future, and there appears to be a declining need for the use of existing aeromedical facilities for the training and indoctrination of conventional pilots. Current military plans emphasize the use of unmanned ballistic missiles. Although certain forward-looking elements at various points in the Military Establishment foresee a tactical need for manned vehicles in space, such weapons systems do not form a major part of current operational plans. The military budgets for aeromedical research are not, therefore, defended at present on the basis of a clearly defined existing military objective or requirement. They depend for the most part on the declining momentum of the conventional aircraft program and the existence of a few experimental projects of which the X–15 and Dyna-Soar vehicle series are examples. For completeness, it may be noted also that understanding of aerospace medicine benefits indirectly by research funded for other reasons. For example, work on hot, noisy environments desired by the Tank Corps may help in understanding some of the biological problems involved in satellite launchings; closed ecological systems under development for use in submarines may be adapted to space vehicles; and so on.

Somewhat paradoxically, NASA, which does have a clearly defined mission to put and maintain men in space, has essentially no existing capability for studying the biological and medical problems involved. Faced with the necessity for selecting a group of astronauts for Project Mercury and providing for their safety during this series of missions, the Agency turned for assistance to the military services. The services, in turn, have responded with enthusiasm and good will to this new challenge. In spite of the apparent success of the arrangement, the fact remains that authority for insuring the health, safety, and effective functioning of the astronauts is not firmly in the hands of the agency responsible for the success of the project as a whole. The medical personnel were not selected by the NASA but

by representatives of the military services which provided them on a loan basis for this particular task. Their continued presence in the project is as much a matter of continuing good will as it is a clear contractual agreement, and the individuals themselves must of necessity feel a primary loyalty to the services in which they have elected to develop their entire careers.

The establishment of an Office of Life Sciences in NASA will greatly improve its capability for discharging its biomedical responsibilities. Even though the Agency will probably wish to continue to draw on many other sources for help in solving its biological problems, the presence of at least a small staff of highly qualified biologists and medical men is essential for the formulation of overall policy, the direction of research and operations within the NASA, and the negotiation of satisfactory working agreements with other Government agencies and the military services.

For the next few years, and possibly indefinitely, the NASA will need to rely heavily on the military services for help in the technology or applied aspects of aeromedicine. For reasons outlined above, the military services presently appear to possess a capability in excess of their own need and are anxious to cooperate in every possible way. The Committee was impressed by the ease with which NASA has arranged cooperative research between individual and small groups of workers in the military laboratories. It is apparent that personnel may be lent from one agency to another, apparatus may be transferred or time made available at military installations with a minimum of administrative difficulty so long as the scale of the operation is kept reasonably small. All those who provided information for the Committee were unanimous on this point.

The situation is far more dubious with respect to large or long-continued programs involving extensive transfer of personnel, facilities, or funds. Complex contracts of this character would doubtless have to be channeled to rather high levels in the Department of Defense with concomitant delays and uncertainties. A more serious question involves the overall Government policy in relation to the budget. To what extent will or should the Bureau of the Budget or the Congress permit the transfer of segments of the NASA budget to other agencies for the execution of NASA directed and supervised objectives? To put the question another way, how far can the military services go in justifying the salaries and allowance of military personnel a substantial part of whose time is spent on civilian missions?

Another difficulty arises from the fact that the apparent excess of space medical capability now available in military establishments may be temporary. How far the present cordial cooperativeness of military personnel is dependent on this temporary excess is difficult to determine, but the possibility cannot be ignored. The present situation is at best an unstable one. Either of two things may happen. The military decision to rely heavily on unmanned ballistic or guided vehicles may become more firmly established. This will lead to a further decline in military requirements for aeromedicine with concomitant budget cuts for the support of aeromedical installations. Conversely, and in the opinion of the Committee more probable, present skepticism in regard to the utility of manned military vehicles will gradually disappear and the services will be provided with increased

funds for research in space medicine. In either case, the excess military capability now available to NASA is likely to decline if not completely disappear.

Faced by these considerations the Committee makes the following recommendations:

1. The Applied Medicine and Biology Section of the proposed Office of the Life Sciences should, in the immediate future, make the fullest possible use of the excellent facilities and personnel for biomedical research now available in the military services. The exact mechanisms for this cooperation must be worked out in large part by the Administrator, the Director of the Life Sciences, and his staff together with the proposed Section on Extramural Research. In many cases, the necessary arrangements can be based on informal agreements to assign personnel or make facilities available. In others, formal contracts guaranteeing definite sums of money over stated periods of time will be necessary. In order to facilitate the negotiating of such arrangements, additional liaison machinery should be set up between the Department of Defense and NASA in the life sciences. This might well be a committee composed of the directors of bioastronautics of the Air Force and Navy, the Director of the Office of Life Sciences, and the Assistant Director for the applied medicine and biology programs of NASA. This committee should be empowered by general directives from the Department of Defense and NASA to work out contractual and other arrangements for the conduct of research and development in aerospace medicine.

A civilian-military liaison committee is in existence to arrange for cooperative interagency undertakings. It is felt, however, that astromedical matters involve quite different considerations from those regularly dealt with by the civilian-military liaison committee. The amounts of money involved are much smaller and other factors in the situation are such as to make it unlikely that the human problems of space flight will get the attention their importance merits unless they are dealt with by a specially constituted group.

2. As soon as possible the NASA Applied Medicine and Biology Section should develop an inhouse capability for research and development as part of the intramural program recommended in section IV–B.

The exact extent of inhouse capability cannot be foreseen at this time. In view of the uncertain availability of military facilities in which much of the immediate research program must be developed, it seems wise to recommend that the long-term program include facilities for the study of every aspect of bioastronautics except those which involve heavy expenditures for special items of equipment.

3. The provision of adequate access to large and expensive apparatus raises special problems. At the present time, the most notable example is the human centrifuge for simulating space flight problems at Johnsville. In most instances, one such installation should be enough to serve the national interest, if proper arrangements are made in advance for its construction and utilization. The present practice is that one or another of the services develops a given installation to meet its own needs and then invites or allows the other services to use it on the basis of ad hoc agreements. The Committee wishes to recommend that in the future such facilities be planned and operated on an explicit NASA-interservice basis. Various adminis-

trative patterns may be thought of to achieve this end. In some cases the facility might be set up as an independent authority with its own budget to provide research service to other Government agencies much as the Bureau of Standards does now. In other instances the facility could be held and operated by a NASA-interservice committee with a budget provided by one or more of these services represented on the committee. This pattern has worked well for the Armed Forces Institute of Pathology.

"E. TRAINING"

In common with every agency of Government and industry which utilizes and depends upon scientific and technical specialists, NASA has a stake and responsibility in the education and training of such men and in the continued supply of scientific manpower generally. An agency which attempts completely to fulfill its responsibilities in this area may recognize a dual nature in these responsibilities. It is, of course, necessary to create and maintain a cadre of scientists properly equipped with the specialized knowledge, skills, motivation, and philosophy which are required for the particular mission; but it is also important that this be done without depletion of other important activities which include national defense, health, aviation medicine, and the basic biological, medical, and behavioral disciplines upon which these areas depend.

The Committee recommends that NASA take immediate steps to initiate a diversified program of training and the support of training administered by the Office of Life Sciences through the Section on Extramural Activities and that in the planning of such a program attention be given to the following types of activities:

1. Postgraduate fellowships or traineeships at NASA installations, at space biology institutes, or in certain laboratories of the Armed Forces, the U.S. Public Health Service and other governmental operations, or at appropriate departments in universities here and abroad for individuals, including members of NASA staff, foreign scientists and others, who have chosen a career in astrobiology, space medicine, or immediately related fields.

2. Training grants to appropriate institutes or university departments to support existing teaching activities or initiate new ones in areas of general or special relevance to the NASA Life Sciences Division.

3. Short-term visiting scientist appointments (from 2 months to 2 years) to permit qualified scientists from this country and abroad to utilize certain of the special facilities of NASA or the Armed Forces in research of relevance to the life sciences program.

"F. COMMUNICATION AND INFORMATION"

The Committee, in common with scientists generally, believes that the primary purpose of science, which is to increase man's understanding of the universe, is best fulfilled by free exchange of scientific findings, information, and criticism among all scientists. The Congress, in establishing this agency, declared "that it is the policy of the United States that activities in space should be devoted to

peaceful purposes for the benefit of all mankind." To this end, the Committee recommends that NASA give serious thought to those mechanisms and guarantees which will facilitate free scientific interchange with respect to the life sciences program. Among those which the Committee has considered and which it supports are the following:

1. Judicious use of travel funds to permit the exchange of information between individual scientists, or among scientists at national or international meetings and symposia without arbitrary restrictions but guided by the value of such interchange to the advancement of knowledge.

2. The sponsorship by NASA of bulletins, journals, and of conferences, meetings, and symposia on topics or in fields where such media or opportunities for exchange of information would be of value.

3. The establishment of a policy of the free reporting of all scientific information obtained in the life sciences through the extramural or intramural operations of NASA in the open scientific literature. Security regulations with respect to personnel or publications and in the areas of grants, contracts and fellowships must be exercised with great caution and limited to those specific projects where a direct relationship to national security can be clearly demonstrated.

"G. NASA LIFE SCIENCES FACILITIES AS A PUBLIC TRUST"

Although much basic research related to problems of space can be conducted in appropriate facilities on earth, it is apparent that many observations must be made in space vehicles. The study of the effect of weightlessness is an obvious example; spectrographic analysis of the surface of the planets from platforms high above the disturbing influences of the earth's atmosphere is another. For some time to come, the space available for scientific instruments in space vehicles is likely to be strictly limited. At the present time almost all such space and bandwidths available for telemetry are being absorbed by the equipment necessary to monitor the function of the vehicle itself or to make limited physical observations of its immediate environment. Prospective improvement of propulsion systems will soon provide more commodious vehicles, but for years to come the supply of facilities is likely to be far less than the demand. Proper allocation of such space facilities will be very difficult to arrange and certainly cannot much longer be left solely to the good will of those responsible for the design and operation of launching equipment, or to random excitement as to who can inject the largest mammal into orbit.

Attention may be drawn to the fact that at present two great powers between them enjoy a monopoly on operations in space. Although this list may be expanded somewhat in years to come, the extensive resources needed to support such missions make it likely that they can be carried out only by the very largest nations. It is a tradition of long standing in the United States that a monopoly position carries with it the obligation to conduct affairs with due regard to the public interest. In the present instance the monopoly is essentially worldwide, since it includes the control not only of the vehicles themselves but of the most suitable launching sites throughout the world. It fol-

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lows that these facilities should be administered so far as it is possible in the public interest of the world at large. The Committee is heartened by the provisions which the NASA has made towards greater international cooperation. As man stands before the moment when at last he may break the bonds which have chained him to a single planet, it seems fitting and proper to insure that all mankind, and not two nations alone, should have the opportunity to meet this momentous challenge.

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PART III. DEPARTMENT OF DEFENSE

OFFICE OF THE DIRECTOR OF
DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C., April 15, 1960.

DEPARTMENT OF DEFENSE SUMMARY COMMENTS FOR THE SENATE COMMITTEE ON AERONAUTICAL AND SPACE SCIENCES STUDY OF BIOLOGICAL, MEDICAL, AND PSYCHOLOGICAL RESEARCH PROGRAMS

The following comments and the accompanying collected reports from the three military services are in response to a request from the committee dated March 23, 1960.

Scope of the study within the Department of Defense: The accompanying reports provide detailed information from 31 laboratories, contracts, and grants offices, and other agencies whose research, development, test, and evaluation programs support aeronautical and space activities either directly or indirectly, in part or in full.

With regard to the Department of the Army reports covering eight laboratories, it should be understood that the Army currently has no formal responsibility for undertaking life sciences research programs in direct support of aeronautical and space activities. This explains the notation "not applicable" which appears in the Army reports. In addition, it explains what might appear to be discrepancies in the sizes and completeness of the research staffs shown in the reports. On the other hand, the reporting Army agencies do conduct research programs which are of considerable indirect interest to the life sciences aspects of aerospace activities. With regard to Army contract programs in the life sciences, the principal agency involved is the Army Medical Research and Development Command, Washington, D.C.

A. OVERALL DEPARTMENT OF DEFENSE FISCAL SUMMARY FOR AEROSPACE RELATED LIFE SCIENCE PROGRAMS

Departments	Research budgets		Present value of installations
	Fiscal year 1960	Fiscal year 1961	
Air Force	$23,256,664	$27,135,669	$31,618,893
Navy	5,955,000	6,476,000	30,018,546
Army	3,425,800	4,413,000	
Total	32,637,464	38,024,669	61,637,439

B. Overall Department of Defense Staffing Summary for Aerospace Related Life Science Programs

Departments	Doctors [1]		Master's		Bachelor's		Supporting staff [2]		Total
	Military	Civilian	Military	Civilian	Military	Civilian	Military	Civilian	
Air Force	186	139	104	121	146	167	75	209	1,147
Navy	74	87	12	58	20	90	161	205	707
Army	13	93	3	95	20	284	----------	438	946
Total	273	319	119	274	186	541	236	852	2,800

[1] Includes M.D.'s, Ph. D.'s, dentists, veterinarians.
[2] Includes technicians, stenographers, and other support personnel.

C. Tri-Service Life Science Programs

1. Armed Forces Institute of Pathology

The Armed Forces Institute of Pathology is the principal Department of Defense organization for consultation, education, and research in pathology, which is the study of disease. It is located on the grounds of the Walter Reed Army Medical Center, Washington, D.C. Originated in 1862 as the Army Medical Museum, it has undergone several stages of growth culminating in 1949 with its establishment as an integrated agency of the Department of Defense, staffed by members of each of the military departments as well as by other Government agencies including the Veterans' Administration and the U.S. Public Health Service.

The mission of the Institute is to support the Medical Services of the Armed Forces by providing consultation, education, and research in pathology. The Institute is authorized by special arrangement to furnish the same support to other Federal organizations and to civilian medicine within the limits of its capabilities.

The Armed Forces Institute of Pathology is organized in four main divisions: The Department of Pathology; the Medical Illustration Service; the Medical Museum; and the American Registry of Pathology, which relates the Institute activities with civilian medicine through the National Academy of Sciences. It is under the management control of the Secretary of the Army through the Army Surgeon General. Its directorship rotates among the three armed services and its Board of Governors consists of the three Surgeons General of the Armed Forces. It has a scientific advisory board composed of some 20 outstanding civilian scientists.

The research program is coordinated by the Scientific Director. Although the bulk of the Institute's research is concerned with diseases which are important to the health and effectiveness of the Armed Forces, an increasing proportion of the research activity is concerned with military environmental pathology which includes problems connected with aerospace activities.

Projects concerned with aeronautical and space activities

Aviation pathology.—This project is concerned with "on-the-scene" and laboratory investigations of human and environmental factors in aircraft accidents such as preexisting disease in the pilot, hypoxia, carbon monoxide or other chemical or drug intoxications, explosive

decompression of pressure cabins, or exposure to fire. The pattern and sequence of injuries may point to mechanical failure or improper design of the aircraft or its equipment.

Radiation studies.—Studies are in progress on the biologic effects of cosmic radiation, nuclear radiations, and microwaves (radar). These investigations involve close collaboration with military and NASA interests and are integrated so as to complement similar work in other laboratories.

Project Mercury support.—The Institute has collaborated in studies of the biologic effects of and tolerance to abrupt decelerative forces in connection with the Mercury capsule design. In addition, it has been requested to provide pathology service support for Project Mercury including studies of the experimental animals.

Toxicology of closed environmental systems.—Methods are being developed to detect and measure minute amounts of substances in human tissues and otherwise, which might accumulate to hazardous levels in closed environmental spaces such as submarines and space capsules.

FISCAL DATA

The research support for fiscal year 1960 amounts to approximately $650,000. The estimated figure for fiscal year 1961 is approximately $900,000. The Armed Forces Institute of Pathology conducts part of its research program through grants and contracts from other agencies, including the military departments. The balance of its research is supported by operating funds.

Contracts and grants.—Of the total research dollars shown above, grants and contracts provide $315,570 in the fiscal year 1960 program and will provide an estimated $500,000 in the fiscal year 1961 program.

Staff.—The total staff numbers 523 persons. Of these, 89 are professional personnel including 23 military physicians, 32 civilian physicians, 4 dentists (3 military, 1 civilian), 11 military veterinarians, and 19 allied scientists (8 military, 11 civilian). The remainder of the staff is composed of subprofessional personnel and administrative support personnel. In addition, there are in training at any one time approximately 60 individuals in military and civilian fellowships in the various branches of pathology.

D. Coordination of Research Programs and Exchange of Information

Coordination and information exchange within the Department of Defense

The Office of the Director of Defense Research and Engineering is responsible to the Secretary of Defense for coordination of all research, development, test, and evaluation programs of the three military departments and the Advanced Research Projects Agency. This is a large part of the daily activity of the 231 scientific and administrative personnel of the ODDR&E and of the corresponding offices in the three military departments. The ODDR&E is aided in this effort by a number of advisory groups, the principal of which is the Defense Science Board whose membership includes outstanding authorities for all major scientific and technical areas of importance to national defense (see p. 63).

The Advisory Panel on Medical Sciences and the Advisory Panel on Psychological and Social Sciences are the two main civilian scientific advisory groups which assist the Director of Defense Research and Engineering in the life sciences areas. (See pp. 65–66.) The chairmen of these panels are ex officio members of the Defense Science Board.

An internal group serving the Director of Defense Research and Engineering, known as the Coordinating Committee on Science, is made up of military and civilian members of the three military services and the Office of the Secretary of Defense; supporting it are coordinating representatives from each of the three services in the several basic research areas of importance to the Department of Defense including representatives for biology, medicine, and psychology and the social sciences. (See p. 67.) Each of the military departments has a top level scientific advisory body whose membership, as in the groups mentioned above, includes authorities in essentially all of the science areas of interest. These bodies are the Air Force Scientific Advisory Board, the Army Scientific Advisory Panel and the Naval Research Advisory Committee.

Among the most important interservice agencies for coordination and exchange of research program information are the Armed Forces-National Research Council scientific committees. Of primary interest to the present report is the Armed Forces-National Research Council Committee on Bio-Astronautics which includes many service members who are specialists in the various aerospace life sciences. (See p. 226.) Similarly, the Armed Forces-National Research Council Committees on Vision and on Hearing and Bioacoustics effect major coordination and interchange among the three services and the civilian scientific community.

Two important scientific information agencies supported in part by the Armed Forces are the Bio-Sciences Information Exchange of the Smithsonian Institution (see p. 241) and the National Research Council Toxicological Advisory Center. The Armed Services Technical Information Agency, operated by the Air Force for the Department of Defense, is the predominant internal activity for collection and dissemination of scientific information to the three military services, their contractors, and to other federal agencies.

In addition to the above-mentioned activities, levels of coordination and the exchange of information include continuous informal contacts among laboratory scientists, both intraservice and interservice, and with other Federal and civilian scientific groups. This is accomplished by a variety of methods, including letters, telephone, laboratory visits, conferences and symposia. It is augmented by the periodic major conferences of the national professional scientific societies whose membership includes many scientists from the Armed Forces. Some of the important ones for the aerospace life sciences are the Aerospace Medical Association, the American Psychological Association, the Federation of American Societies for Experimental Biology, and the American Institute of Biological Sciences.

Coordination and information exchange with other federal agencies and with non-governmental scientific groups

One of the benefits of joint civilian-military membership in the several scientific advisory groups mentioned above is the resultant op-

portunity for dissemination of program information through the civilian members who represent the Nation's universities, private research groups, and industrial research groups.

Liaison officers provide an important channel for interagency coordination. For example, the Air Force has a group of officers, including biomedical specialists, assigned full time with the Atomic Energy Commission. Each service has scientists working full time with the NASA. The Assistant Secretary of Defense (Health and Medical) and the three Surgeons General designate medical specialists to serve part time with the research advisory councils and study sections of the U.S. Public Health Service. The Assistant Secretary of Defense (Health and Medical) is a member of the President's Federal Radiation Council.

A coordinating link with the National Aeronautics and Space Administration is the NASA-DOD Space Science Committee. (See p. 67.) Program information in the life sciences is included in the deliberations of this group.

The daily informal coordinating activities of defense research managers and laboratory scientists communicates information to and from other Federal agencies and the civilian scientific community and utilizes a number of different communications techniques. In addition, for unclassified research and development material the public news media and the scientific and technical journals provide a continuing body of useful and timely information concerning activities in military research and development.

1. Defense Science Board

Dr. H. P. Robertson, Chairman.
Dr. J. W. McRae, Vice Chairman.
L. M. McKenzie, Executive Secretary.

Executive Committee

Dr. H. P. Robertson, Chairman.
Dr. J. W. McRae, Vice Chairman.
Dr. R. W. Cairns.
Dr. C. C. Furnas.
Members ex officio: Chairmen (and designees) of ODDR&E advisory panels:

Aeronautics: William Littlewood, vice president, equipment research, American Airlines.

Atomic Energy: Dean Dale R. Corson, College of Engineering, Cornell University.

Biological and Chemical Warfare: Dr. Frank L. Horsfall, Jr., vice president and physician in chief, the Rockefeller Institute.

Electronics: Dr. Elmer W. Engstrom, senior executive vice president, Radio Corp. of America.

Fuels and Lubricants: Dr. W. J. Sweeney, vice president, Esso Research & Engineering Co.

General Sciences: Dr. R. W. Cairns, director of research, Hercules Powder Co.

Materials: Dr. C. F. Rassweiler, vice president for research and development, Johns-Manville Corp.

Medical Sciences: Dr. Richard A. Kern, Temple University Hospital, Philadelphia, Pa.

Ordnance: Dr. Thomas E. Caywood, Caywood-Schiller Associates, Chicago, Ill.

Psychology and Social Sciences: Dr. Dael Wolfle, executive officer, American Association for the Advancement of Science.

Chairmen (and designated alternates) of advisory bodies:

Army Scientific Advisory Panel:

Dr. James W. McRae, vice president, American Telephone & Telegraph Co.; and Chairman, Army Scientific Advisory Panel, Department of the Army.

Alternate: Dr. C. C. Furnas, chancellor, the University of Buffalo.

Naval Research Advisory Committee:

Dr. Frederick Seitz, head, Department of Physics, University of Illinois; and Office of Scientific Adviser, North Atlantic Treaty Organization, Paris, France (for 1 year); and Vice Chairman, Naval Research Advisory Committee, Washington, D.C.

Air Force Scientific Advisory Board:

Lt. Gen. Donald L. Putt, USAF (Ret.), President, United Research Corp. of Menlo Park, Menlo Park, Calif.; and Chairman, Scientific Advisory Board, Department of the Air Force.

Alternate: Dr. H. Guyford Stever, associate dean of engineering, Massachusetts Institute of Technology.

Scientific Advisory Committee, Office of the Secretary of Defense: Dr. Clark B. Millikan, director, Guggenheim Aeronautical Laboratory, California Institute of Technology.

President's Science Advisory Committee: Dr. George B. Kistiakowsky, Special Assistant to the President for Science and Technology.

General Advisory Committee, Atomic Energy Commission: Dr. Warren C. Johnson, vice president in charge of special scientific programs, the University of Chicago.

Representatives of other agencies:

Dr. Allen V. Astin, Director, National Bureau of Standards.

Dr. Detlev W. Bronk, President, National Academy of Sciences.

Dr. Hugh L. Dryden, Deputy Administrator, National Aeronautics and Space Administration.

Dr. Alan T. Waterman, Director, National Science Foundation.

Members-at-large:

Frank R. Collbohm, president, the Rand Corp.

Dr. C. C. Furnas, chancellor, the University of Buffalo.

Dr. A. B. Kinzel, vice president, Union Carbide Corp.

Dr. H. P. Robertson, professor of mathematical physics, California Institute of Technology; and Chairman, Defense Science Board, Office of the Director of Defense Research and Engineering.

Dr. L. Eugene Root, group vice president, Lockheed Aircraft Corp.

Dr. Wilbur Schramm, Center for Advanced Study in the Behavioral Sciences, Stanford University.

Maj. Gen. Leslie E. Simon, USA (retired), vice president and director, R. & D., Carborundum Co.

Executive Secretary: Lawson M. McKenzie, Office of the Director of Defense Research and Engineering.

2. Advisory Panel on Medical Sciences

Steering group:

Dr. Richard A. Kern, Chairman; Temple University Hospital, Philadelphia, Pa.

Dr. Truman G. Blocker, Jr., professor of surgery, University of Texas Medical Branch.

Dr. Donald W. Hastings, professor of psychiatry and neurology, Medical School, University of Minnesota.

Dr. Waltman Walters, professor of surgery, Mayo Foundation, University of Minnesota.

Members:

Dr. J. Garrott Allen, Department of Surgery, Stanford University School of Medicine.

Dr. Stanhope Bayne-Jones, Washington, D.C.

Dr. Harwood S. Belding, professor of environmental physiology, University of Pittsburgh.

Dr. R. Keith Cannan, Chairman, Division of Medical Sciences, National Research Council.

Dr. Louis E. Daily, vice president, Eaton Laboratories, Norwich, N.Y.

Dr. Donald H. Eldredge, Central Institute for the Deaf, St. Louis, Mo.

Dr. Gioacchino Failla, professor of radiology and director of laboratory, College of Physicians and Surgeons, Columbia University.

Dr. Lee E. Farr, medical director, Brookhaven National Laboratory.

Dr. Frank Fremont-Smith, medical director, Josiah Macy, Jr., Foundation.

Dr. Maynard K. Hine, dean, School of Dentistry, Indiana University.

Dr. Harold C. Hodge, professor of pharmacology and toxicology, School of Medicine and Dentistry, University of Rochester.

Dr. Lawrence C. Kolb, director, New York State Psychiatric Institute, New York, N.Y.

Dr. Christian J. Lambertsen, professor of pharmacology, Laboratory of Pharmacology, University of Pennsylvania.

Dr. Clarence S. Livingood, chairman, Department of Dermatology, Henry Ford Hospital, Detroit, Mich.

Dr. W. Randolph Lovelace II, director, Lovelace Foundation, Albuquerque, N. Mex.

Dr. Ross A. McFarland, professor of environmental health and safety, Harvard University School of Public Health.

Dr. Lloyd R. Newhouser, director, Blood Bank and Medical Research Foundation, Miami, Fla.

Dr. Dan C. Ogle, president, Institute of Physical Medicine and Rehabilitation, Peoria, Ill.

Dr. Donald M. Pillsbury, Department of Dermatology, Duhring Laboratories, University of Pennsylvania.
Dr. Herbert Pollack, associate professor of clinical medicine, New York University School of Medicine.
Dr. Harold G. Scheie, professor of ophthalmology, University of Pennsylvania.
Prof. Leslie Silverman, professor of engineering in environmental hygiene, Harvard University School of Public Health.
Dr. Joseph E. Smadel, Associate Director, National Institutes of Health.
Dr. Scott N. Swisher, School of Medicine and Dentistry, Strong Memorial Hospital, University of Rochester.
Col. John M. Talbot, USAF, MC, Secretary, Advisory Panel on Medical Sciences, Office of Director of Defense R. & E.

3. Advisory Panel On Psychology And Social Sciences

Steering group:
Dr. Dael L. Wolfle, chairman, American Association for the Advancement of Science.
Dr. John L. Kennedy, Department of Psychology, Princeton University.
Dr. Klaus Knorr, Center for International Studies, Princeton University.
Dr. Arthur W. Melton, Department of Psychology, University of Michigan.
Dr. Ithiel deSola Pool, Center for International Studies, Massachusetts Institute of Technology.
Dr. Charles A. H. Thomson, the Rand Corp.
Dr. Morris Janowitz, University of Michigan.

Members:
Dr. William C. Biel, System Development Corp., Santa Monica, Calif.
Dr. Charles W. Bray, the Smithsonian Institution.
Dr. Leonard Carmichael, the Smithsonian Institution.
Dr. Leonard S. Cottrell, Jr., Russell Sage Foundation.
Dr. Phillips Davison, the Rand Corp.
Dr. Glen Finch, National Research Council, Washington, D.C.
Dr. Paul M. Fitts, Department of Psychology, University of Michigan.
Dr. Frank A. Geldard, Department of Psychology, University of Virginia.
Dr. Harry F. Harlow, Department of Psychology, University of Wisconsin.
Dr. Roger W. Heyns, Department of Psychology, University of Michigan.
Dr. William A. Hunt, Department of Psychology, Northwestern University.
Dr. Paul M. Linebarger, School of Advanced International Studies, Washington, D.C.
Edwin A. Link, Link Aviation Co.
Dr. Leonard C. Mead, Department of Psychology, Tufts University.

Dr. Aaron B. Nadel, General Electric Co.
Dr. Russell D. O'Neal, Systems Division, Bendix Aviation Corp.
Dr. Jesse Orlansky, Dunlap & Associates, Stamford, Conn.
Dr. Henry Riecken, National Science Foundation.
Dr. John W. Riley, Jr., Department of Sociology, Rutgers University.
Dr. Phillip J. Rulon, Harvard University Graduate School of Education.
Dr. Philip B. Sampson, Department of Psychology, Tufts University.
Dr. Wilbur Schramm, Center for Advanced Study of the Behavioral Sciences, Stanford University.
Dr. Philip Selznick, Department of Sociology, University of California.
Dr. Carl Pfaffmann, Brown University.

4. Coordinating Committee on Science [Life Science Members]

Astronomy and Astrophysics.
Biology:
Army: Dr. R. G. H. Siu; alternate, Dr. J. M. Leise.
Navy: Dr. Roger D. Reid.
Air Force: Chairman, Dr. A. W. Hetherington.
Cartography and Geodesy.
Chemistry.
Earth Physics.
Geography.
Mathematics.
Mechanics.
Medicine:
Army: Brig. Gen. Joseph H. McNinch; alternate, Lt. Col. J. B. Hartgering.
Navy: Chairman, Capt. J. R. Kingston.
Air Force: Col. Charles H. Roadman.
Meteorology.
Oceanography.
Physics.
Polar Research and Development.
Psychology and Social Sciences:
Army: Dr. L. E. Baker; alternate, Col. Charles W. Hill.
Navy: Dr. D. D. Smith.
Air Force: Lt. Col. Donald C. Almy.

5. NASA-DOD Space Science Committee

Dr. Homer E. Newell, Jr., Chairman; National Aeronautics and Space Administration.
Dr. J. F. Clark, National Aeronautics and Space Administration.
Dr. Richard W. Davies, Jet Propulsion Laboratory, California Institute of Technology.
Dr. James B. Edson, Chief Scientist for Missiles, Office, Assistant Chief of Staff, Intelligence, Department of the Army.
Dr. Herbert Friedman, Superintendent, Atmosphere and Astrophysics Division, Naval Research Laboratory.

Stanley M. Greenfield, scientific adviser, Directorate of Research and Development.
Dr. John T. Holloway, Chief, Physical Sciences, Office of Science, Office of the Director of Defense Research and Engineering.
Dr. Frank C. Hoyt, Space Technology, Advanced Research Projects Agency/Institute for Defense Analysis.
Dr. Geoffrey Keller, Program Director for Astronomy, National Science Foundation.
W. J. O'Sullivan, Jr., Langley Research Center, National Aeronautics and Space Administration.
John W. Townsend, Jr., Goddard Space Flight Center, National Aeronautics and Space Administration.
Dr. Henry E. Stauss, Secretary, National Aeronautics and Space Administration.

DEPARTMENT OF THE AIR FORCE

A. Department of the Air Force Fiscal Summary for Aerospace Related Life Science Programs

Installations	Research budget		Present value of installation
	Fiscal year 1960	Fiscal year 1961	
Aerospace Medical Laboratory	$6,866,000	$8,363,000	$9,186,877
USAF School of Aviation Medicine	5,823,000	5,300,000	8,496,017
Aeromedical Field Laboratory	1,638,000	2,089,000	7,238,000
Personnel Laboratory	1,727,784	1,792,517	779,897
Life Sciences Directorate, Air Force Research Division	1,990,000	2,010,000	
Biophysics Division, Air Force Special Weapons Center	745,000	1,500,000	679,000
Operational Applications Laboratory	1,321,000	707,000	250,000
Arctic Aeromedical Laboratory	895,000	1,038,500	2,384,436
Directorate of Air Force Bioastronautics, Air Force Ballistic Missile Division	308,000	2,100,000	
Human Engineering Laboratory	478,000	560,000	270,000
Human Factors Branch, Air Force Flight Test Center	387,800	550,000	2,124,666
Human Factors Office, Air Proving Ground Center	235,080	203,652	10,000
Training Equipment Branch, Aeronautical Accessories Laboratory	822,000	922,000	200,000
Total	23,256,664	27,135,669	31,618,893

B. Department of the Air Force Staffing Summary for Aerospace Related Life Science Programs

Installations	Doctors [1]		Masters		Bachelors		Supporting staff [2]		Total
	Military	Civilian	Military	Civilian	Military	Civilian	Military	Civilian	
Aerospace Medical Laboratory	31	41	32	46	41	60	39	142	441
USAF School of Aviation Medicine	73	32	21	21	75	55	10	9	296
Aeromedical Field Laboratory	59	5	6	2		19	5	16	115
Personnel Laboratory	3	25	8	18	9	9	9	11	92
Life Sciences Directorate, AF Research Division	2	4						2	8
Biophysics Division, AF Special Weapons Center	8	1	14		14	2	3	6	48
Operational Applications Laboratory	1	17	5	10	1	3	1	7	45
Arctic Aeromedical Laboratory	5	5	2	7	2	1	7	11	40
Directorate of AF Bioastronautics, AF Ballistic Missile Division			3		1			2	6
Human Engineering Laboratory	2	4	4	10		3			23
Human Factors Branch, AF Flight Test Center	1		5		1		1	1	9
Human Factors Office, Air Proving Ground Center	1	2	3	5	2	2			15
Training Equipment Branch, Aeronautical Accessories Laboratory			1	2		4		2	9
Total	186	139	104	121	146	167	75	209	1,147

[1] Includes M.D.'s, Ph. D.'s, dentists, veterinarians.
[2] Includes technicians, stenographers, and other support personnel.

C. Life Science Programs

1. Aerospace Medical Laboratory, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio.
2. USAF School of Aviation Medicine, Aerospace Medical Center, Brooks Air Force Base, Tex.
3. Aeromedical Field Laboratory, Air Force Ballistic Missile Development Center, Holloman Air Force Base, N. Mex.
4. Personnel Laboratory, Directorate of Advanced Systems Technology, Wright Air Development Division, Lackland Air Force Base, Tex.
5. Life Sciences Directorate, Air Force Office of Scientific Research, Air Force Research Division, Washington, D.C.
6. Biophysics Division, Research Directorate, Air Force Special Weapons Center, Kirtland Air Force Base, N. Mex.
7. Operational Applications Laboratory, Air Force Command and Control Development Division, L. G. Hanscom Field, Mass.
8. Arctic Aeromedical Laboratory, Ladd Air Force Base, Alaska.
9. Directorate of Air Force Bioastronautics, Military Space Systems, Air Force Ballistic Missile Division, AF Unit Post Office, Los Angeles, Calif.
10. Human Engineering Laboratory, Rome Air Development Center, Griffiss Air Force Base, N.Y.
11. Human Factors Branch, Air Force Flight Test Center, Directorate of Flight Test, Edwards Air Force Base, Calif.
12. Missile Test and Range Support Division, Office of the Staff Surgeon, Air Force Missile Test Center, Patrick Air Force Base, Fla.
13. Human Factors Office, Air Proving Ground Center, Eglin Air Force Base, Fla.
14. Training Equipment Branch, Simulator Research Section, Aeronautical Accessories Laboratory, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio.

1. Aerospace Medical Laboratory, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio

The Aero Medical Laboratory was established in 1942 as a component of the Air Materiel Command Engineering Division. The original efforts were directed toward basic research in biophysics and physiology as related to the effects of high altitude and acceleration.

The mission of the Aerospace Medical Laboratory is to achieve maximum effectiveness of man in performing his functions in advanced systems. This is being accomplished through research programs in the biomedical and behavioral sciences and through research on new concepts of equipment for sustaining man under adverse environments.

Current major programs

The current major research programs are: (1) Research on life support systems, (2) Toxicity and health hazards on materials and radiation, (3) Acoustic energy control, (4) Human factors in nuclear

operations, (5) Human factors in design of training equipment, (6) Manning and personnel training requirements, (7) Functional analogs of living systems, (8) Human performance in advanced systems, (9) Acceleration in flight, and (10) Physiology of man in space and in isolation. The above programs include both basic and applied research.

Future anticipated major programs through fiscal year 1970

Future programs will be essentially an extension of the existing programs. However, shifts in emphasis will be made to more directly support specific advanced systems as the needs become apparent.

Authority for present and anticipated future programs at the installations involved

Formal authority for the present programs is given in the following U.S. Air Force approved Applied Research Planning Documents for program areas: Biologistics, Biomechanics, Radiobiology, and Human Performance, and in the Research Planning Objective, Biosciences. It is anticipated that future requirements documents will be systems oriented to a larger extent. These requirements will be stated in terms of the work to be done in support of specific advanced systems.

Suitability of present and planned facilities to the current and assumed future missions through fiscal year 1970

In general, the laboratory facilities are adequate to meet its present mission responsibilities. A nucleus of five buildings, constructed especially to meet its functional requirements, house the majority of its major research equipment. The anticipated acquisition of a new laboratory building, which has been requested in the fiscal year 1961 military construction program will alleviate the present crowded conditions in certain parts of the existing facilities and will free for its originally intended purpose some laboratory space that has had to be used for administration and offices. It is expected that a growing research and development program involving manned space systems for military purposes would require some major equipment additions to the present complex.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services?

The Aerospace Medical Laboratory is adequately equipped and staffed to continue a progressive program in support of military aviation; in addition, its aggregate capabilities would lend themselves well to a variety of investigations of importance to the Armed Forces including the effects of physical stresses on man, and the development of life support and protective equipment for man in a wide variety of military environments.

FISCAL DATA

Budget estimates for present and future programs, fiscal years 1960–62

[In thousands]

Program	Fiscal year 1960		Fiscal year 1961		Fiscal year 1962	
	Contract funds	Noncontract funds	Contract funds	Noncontract funds	Contract funds	Noncontract funds
Research on life-support systems	$896	$128	$850	$112	$1,000	$116
Physiology of man in space and in isolation	1,479	503	1,498	483	1,700	491
Toxicity and health hazards of materials and radiation	436	114	710	114	600	120
Acoustic energy control	317	230	752	215	885	218
Functional analogs of living systems	46	94	815	58	900	82
Human factors in design of training equipment	365	183	595	167	700	171
Human performance in advanced systems	959	383	1,075	367	1,560	371
Manning and personnel training requirements	100	51	85	37	100	39
Human factors in nuclear operations	89	30	170	18	300	18
Acceleration in flight	379	84	170	72	200	72
Total	5,066	1,800	6,720	1,643	7,945	1,698

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories of research

The costs of present contracts to nongovernmental groups by major categories are as follows: Human performance—$1,700,000, which includes the areas of human factors in the design of training equipment, human performance in advanced systems, and manning and personnel training requirements; biologistics—$1,629,000, which includes research on life-support systems, physiology of man in space and in isolation, and toxicity and health hazards of materials; biomechanics—$2,188,000, which includes biophysics of flight and acoustic energy control; basic research—$675,000, which includes the areas of functional analogs of living systems, biophysics research, psychological research on human performance, and physiology research.

The cost of present Government contracts in the area of biologistics, which includes physiology of man in space and in isolation, is $70,000.

Capital investment in overall plant and equipment, both at present and anticipated for future years through fiscal year 1970

Current inventory records show the laboratory holdings are:

Standard Air Force materiel	$361,850
Nonstandard supplies and equipment:	
(*a*) under $500 items (estimated)	700,000
(*b*) $500 and over	1,995,027
Major research and development installed equipment	3,000,000
Buildings (initial construction cost, not including real estate values)	2,895,000
Present total physical assets	8,951,877
Life-support test capsule presently being contractor fabricated	235,000

Anticipated future requirements through fiscal year 1961 are represented by the military construction program item identified below. Its anticipated cost is:

Fiscal year 1961 military construction program Science Laboratory, Medical (310–921): Fully operable, based on accomplished architectural design $2,277,000

Description and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies for fiscal year 1960 and fiscal year 1961

At the present time, the Quartermaster Food and Container Institute is conducting a study to determine changes in food acceptability as well as the physiological effects produced by food monotony. This research has been extended to include investigation of consumption in more stressful activities and consumption trends of men subsisting on a limited variety of repetitively fed canned and dehydrated rations for an extended length of time. Further studies will be made on the food technology of algae to extend food supplies for space flight utilizing the Sorokin strains of *Chlorella*. Funds in the amount of $70,000 have been allocated to these studies. It is anticipated that this work will continue through fiscal year 1961.

The Army Chemical Center is conducting acute inhalation toxicity studies which will facilitate the handling of missile propellants with reasonable safety which is compatible with operational efficiency. Funds in the amount of $183,000 have been allocated for this effort. It is anticipated that this work will continue through 1961.

It is anticipated that support will be given NASA in fiscal year 1961 for on-call work in the areas of noise and vibration, escape-capsule impact studies, pressure-suit studies, and medical monitoring services for these programs. It is estimated that the cost involved in these programs will be primarily manpower at approximately the same level as that rendered in 1959, which was 20,000 man-hours.

54232—60——6

Staff breakdown

DOCTOR OF PHILOSOPHY

	Scientific staff			Technical services staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Biology		1	1				1
Chemistry		1	1				1
Psychology	3	20	23				23
Physiology		5	5				5
Physics		3	3				3
Biochemistry		1	1				1
Bacteriology		1	1				1
Pharmacology		1	1				1
Mathematics		1	1				1
Speech science	1		1				1
Food technology		1	1				1
Industrial psychology		2	2				2
Total	4	37	41				41

DOCTOR OF MEDICINE

Flight surgeon	5		5				5
Aviation medical examiner	3		3				3
Medical officer, general	4	2	6				6
Internist	6		6				6
General surgeon	1		1				1
Psychiatrist	2		2				2
Clinical pathology		1	1				1
Pathology	1		1				1
Neuropathology		1	1				1
Total	22	4	26				26

DOCTOR OF VETERINARY MEDICINE

Veterinary medicine	5		5				5

MASTER'S DEGREES

Anthropology	1	1	2				2
Anatomy		1	1				1
Biology		1	1				1
Biochemistry	3		3				3
Chemistry	1		1	1		1	2
Clinical psychology	2		2				2
Electrical engineering	1	1	2				2
Mechanical engineer	1	1	2				2
Forestry		1	1				1
Mathematics		1	1				1
Nutrition	1	1	2				2
Parasitology	1		1				1
Physiology	3	3	6				6
Psychology	12	32	44				44
Physiological optics	2		2				2
Optometry	1	1	2				2
Speech science		2	2				2
Zoology				2		2	2
Totals	29	46	75	3		3	78

Staff breakdown—Continued

BACHELOR'S DEGREES

	Scientific staff			Technical services staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Biology	4	5	9	5	1	6	15
Zoology		1	1				1
Chemistry	1	3	4	2		2	6
Psychology	8	14	22				22
Physics	5	5	10				10
Mechanical engineer	5	8	13				13
Electrical engineer	4	6	10				10
Anthropology	1	2	3				3
Industrial engineer		2	2				2
Industrial design		1	1				1
Medical technology		2	2				2
Clinical psychology	1		1				1
Clinical pathology		1	1				1
Bacteriology		1	1				1
Premedical	1	1	2				2
Pharmacology	1		1				1
Editorial science		1	1				1
Home economics	1		1				1
Mathematics	1	3	4				4
Physics		1	1				1
Optometry		1	1				1
Chemical engineer	1	4	5				5
Commerce					1	1	1
Business administration					1	1	1
Textiles					1	1	1
Tailoring and cloth					3	3	3
Total	34	62	96	7	7	14	110
Total degrees	94	149	243	10	7	17	260

	Military	Civilian	Total
Supporting personnel:			
Administration and clerical	4	70	74
Miscellaneous support	35	72	107
Total	39	142	181
Total:			
Scientific	94	149	243
Technical service	10	7	17
Supporting	39	142	181
Total	143	298	441

Major physical resources

The Aerospace Medical Laboratory, consisting of management staff, operations office, administration and services branch, and eight mission branches, occupies 19 buildings at present. Occupancy in two of these buildings is on a tenancy basis; six of the buildings are small temporary storage huts which are slated for disposal in the near future, and the remaining are assigned to and used by the Laboratory for direct program activities.

Square feet of floor space

The total is 196,128 square feet.

Special laboratory facilities

The Laboratory complex includes a specially designed bioacoustics research building with a unique 30 by 30 feet anechoic chamber, three coupled reverberation rooms, four audiometry labs, two hearing and speech communication labs, a histopathology lab, animal surgery, and instrumentation shop among other test areas. Another building has

a 30 by 40 feet flotation test pool; a liquid oxygen generation plant, helium cryostat, four-man altitude chamber, and related machinery and test apparatus for respiration equipment development and testing. The physiology laboratory (high altitude research building) includes a multiple chamber installation capable of plus 100,000 feet altitude simulation with coupled auxiliary chambers for explosive decompression and up to 24-man crew studies. It also includes fully equipped biochemical, bacteriology, radioisotope, nutritional, and physiology examination labs. The human thermal tolerance program of the Laboratory is backed-up by two unique environmental chambers: one has the capability for programming six broad range variables of temperature and altitude, the second is an all-weather chamber capable of a wide range of temperature and humidity conditions. The biophysics laboratory building houses a 40-foot boom (20-foot radius) 22 g. centrifuge for acceleration research, instrumentation lab for advanced telemetry development, an anechoic chamber for isolation studies, an anthropometric lab, and areas for related research. The entire program is supported by a vivarium facility occupying space in several buildings which includes animal experimentation, X-ray, surgery, pathology and autopsy labs, plus animal care and holding areas.

Aside from its own facilities, the Laboratory has access to and uses many facilities available in the neighboring physical sciences laboratories; notable at present are escape capsule impact studies utilizing an inclined drop test facility and the continuous services of the centralized major analog/digital computer and data processing facilities of the Wright Air Development Division. The latter are available for indirect linkage for space simulator programing.

Special items of research equipment

The Laboratory's facilities also include the following major installed equipment: a 20-foot amplitude vertical accelerator; a downward ejection seat tower utilized for special biodynamic studies; a 40-foot, 30 g. vertical deceleration tower; another 12-man altitude chamber; a digitron computer, a mobile acoustics and a mobile microbiology laboratory (two specially equipped semi-trailers for field studies); and a specially instrumented C–131B aircraft for zero-gravity and human factors flight experimentation. In addition, a KC–135 jet aircraft is presently in contractor modification and should be available by July 1, 1960, for more advanced zero-gravity research.

2. USAF School of Aviation Medicine, Aerospace Medical Center, Brooks Air Force Base, Tex.

On October 18, 1917, the U.S. War Department issued special orders appointing a Medical Research Board. The first action of this Board was to establish the Air Service Medical Research Laboratory which was activated on January 19, 1918. The Laboratory was moved to Mitchell Field, Long Island, in November 1919, and achieved permanent status when it was designated in February 1921 as a special service school. In November 1922 the name of the Laboratory was changed to the School of Aviation Medicine, thus emphasizing its primary purpose as an educational institution. In June 1926 the school was transferred from Mitchell Field to Brooks

Field, San Antonio, Tex. In October 1931 it was moved again to newly activated Randolph Field, northeast of San Antonio. For over a quarter of a century it was located at that base, where it overflowed into a random collection of temporary structures during the hasty expansion necessitated by World War II. On April 1, 1946, the school was transferred administratively to Air University, where it became the graduate medical department of that institution. In July 1959 the school was moved into new facilities at Brooks Air Force Base, where it occupies 5 new buildings and 45 temporary structures. On October 1, 1959, the school, the USAF Hospital, Lackland Air Force Base, and the USAF Epidemiological Laboratory were combined into the USAF Aerospace Medical Center and assigned to the Air Training Command.

Mission

The mission of the School of Aviation Medicine is threefold:

(1) *Education.*—The school's headquarters at Brooks Air Force Base, Tex., establishes the curriculums and conducts graduate courses in the specialty of aviation medicine for selected medical officers of the USAF and other national defense agencies and medical officers of friendly foreign countries. Courses conducted include the primary course in aviation medicine; the advanced course in aviation medicine, which is the second phase of a 5-year program of academic training and supervised practice that leads to the certification of the doctor as a specialist in aviation medicine; the flight surgeon's refresher course; the review course in aviation medicine, which is offered to medical officers who are preparing to take the annual special Board examination; and a course in aerospace medicine for senior allied officers, flight nurse course, physiological training officer course, physiological training symposium, apprentice aeromedical specialists' course, aeromedical technician course, aeromedical evacuation technician course, apprentice physiological training supervisor course, and personal equipment maintenance course (Phase II: Pressure Suits).

(2) *Research.*—In the field of research, the School of Aviation Medicine conducts or monitors the conduct of basic and applied research in such broad categories as aeromedical training, perceptual problems of flight, medical aspects of flying safety, Air Force preventive medicine, biological aspects of microwave radiation, medical standards in aviation, Air Force clinical medicine, aeromedical problems of atomic energy, aviation physiology, and air evacuation. In addition, this organization furnishes administrative and budgetary support to operational air forces in field aeromedical research and development of crew effectiveness.

(3) *Specialized medical practice.*—In the field of specialized medical practice, the School of Aviation Medicine practices aviation medicine to the extent its facilities permit by providing upon request of Headquarters, USAF, consultative service for flying personnel with difficult, obscure, or borderline diagnostic problems affecting flying status and resolving those problems by authoritative study and opinion.

Current major programs

The School of Aviation Medicine accomplishes its research mission through a vigorous in-house program, as well as by means of con-

tract research at civilian universities, industrial organizations and nonprofit institutions. The 10 broad project areas: Aeromedical Training; Perceptual Problems of Flight; Medical Flying Safety; Air Force Preventive Medicine; Medical Standards in Aviation; Air Force Clinical Medicine; Aeromedical Problems of Atomic Energy; Aviation Physiology; Air Evacuation; Bioastronautics; represent the framework of the entire in-house and contractual programs. These projects are subdivided into 88 specific in-house tasks and 87 individual separate research contracts with outside institutions.

Future anticipated major programs through fiscal year 1970

Efforts in the above-mentioned project areas will be continued in the evolution of the School of Aviation Medicine research programs of the future, only the emphasis will be shifted. At the present time technological advancements in national science indicate deficiencies of knowledge in the fields of aeromedical problems of atomic energy and radiation biology as well as bioastronautics. It is expected that our research efforts will continue to maximize these project areas with an increased interest in nuclear propulsion and auxiliary power sources, i.e., isotope applications. Continued emphasis will be given to biological dose versus effect and increasing emphasis will be directed toward therapy and protection from ionizing radiation. In bioastronautics an increased emphasis will be assigned to closed ecological systems and feasibility studies and basic research leading to the development of efficient lightweight support equipment, i.e., tissue equivalent chambers, waste disposal systems, recycling generators, physiological transmitters, etc. It is anticipated that standardized biological space probes will come into being and actual biological data will be determined as a result of these investigations. Within this time period it is not inconceivable that a biological laboratory will be placed into orbit. This will require increased emphasis in bioinstrumentation and data accumulation and processing. It will be necessary for both basic and applied research to proceed in a concurrent manner so that great strides can be made in advancing our technology as it applies to man in space, whether it be for peaceful purposes or as a requirement for military reconnaissance and/or surveillance.

Authority for present and anticipated future programs

Authority for current research program is contained in appropriate project documents (Defense Department Form 613), individually approved by Headquarters, U.S. Air Force. This existing authority is sufficient to cover the future program as outlined above.

Suitability of present and planned facilities

Pending the construction of seven additional permanent structures at Brooks Air Force Base, currently in the 1961 military construction program, aerospace medical research is presently conducted in four of the five buildings within the new complex and in 10 temporary buildings rehabilitated for research purposes. The functional capability of these research facilities encompasses microbiology-cellular biology, pathology, toxicology, pharmacology, astroecology, bioastronautics radiobiology, physiology, biochemistry, biodynamics, biometrics, and all of the clinical medicine disciplines associated with aerospace medical research.

The Flight Medicine Laboratory, which is the nucleus of the consultation and clinical research program of the school, also supports the astronaut selection program and the evaluation of all clinical abnormalities of flying personnel referred to the school.

The Research Laboratory Shop supports the entire mission of the school with its ultra modern instrumentation fabrication and bioelectronics facilities, i.e., biopacks and bioinstrumentation for space flight. This building also houses a complete photography section. Statistical support through the use of electronic data processing machines is also available here.

The Altitude Laboratory, the most flexible building within the complex, supports the entire research and teaching program in altitude physiology and aviation physiological research. One of its most unique pieces of equipment is the large "E" chamber (20′ x 47′ x 12′).

The Research Institute contains laboratory space for the majority of the scientific disciplines described above. Emphasis is placed on applied and fundamental medical research as it pertains to the airman or astronaut and his environment in operational and future vehicles. The Radiation Section, with its 12,000 curies of cobalt, neutron generator, and isotope facility, significantly enhances the investigations into radiation problems of long-term dose versus effect. One of the world's largest primate colonies, devoted exclusively to long-term acute and chronic irradiation studies, is readily accessible.

As future research emphasis turns toward space travel and nuclear applications, construction of the seven additional buildings to complete the Aerospace Medical complex will markedly increase the research potential in these areas. Programed into this complex is a bionucleonics hazards building devoted to nuclear, biological, and toxicological research; and a biodynamics-bioastronautics building with a small teaching and clinical research centrifuge. In addition, a large, flexible bay area will support various space research simulators, i.e., reaction control simulator, hydroponics studies, disorientation tank, etc.

Additional or other roles in life sciences research requirements of the Armed Forces

In the event that research responsibility in the area of astronautics were to be deleted from the mission of this facility, the School of Aviation Medicine could adequately continue its research program in aviation medicine as it applies to operation of our future weapons systems.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960 and fiscal year 1961)

The financial plan for fiscal year 1960 for the School of Aviation Medicine's research program is $5,823,000. Of this total $2,180,000 is allocated for costs involved in medical research performed by others under contract, fund transfer, or inter-agency agreement; $3,643,000 is allocated for the in-house research program. In addition, $3,250,839 has been allocated in the operation and maintenance appropriation for Brooks AFB which provides necessary administrative support to the School of Aviation Medicine. Comparable figures for fiscal year 1961 are as follows: Total research and development

funding $5,300,000 consisting of $1,900,000 for extramural research and $3,400,000 for in-house research costs; $3,179,782 for operation and maintenance of Brooks Air Force Base. In addition to the fiscal year 1961 funding indicated above, supplemental requests have been made for additional funding of $312,605 in the in-house research area and $538,810 of operation and maintenance funds.

Costs of present and anticipated contracts for medical research

During fiscal year 1960 it is planned to obligate $2,090,000 for contractual research to be performed by nongovernmental groups or educational institutions. During fiscal year 1961 it is planned to obligate $1,854,000 for costs of this nature.

Capital investment

The plant valuation of the newly constructed School of Aviation Medicine complex at Brooks Air Force Base, including equipment permanently installed in the buildings is $8,496,017.75. A detailed breakdown of this valuation is shown in a subsequent paragraph. The value of equipment in use (other than permanently installed equipment) is $3,555,187.59, of which $969,247.04 is attributable to unit allowance list property and $2,585,940.55 is invested in specially authorized—mostly research support—equipment.

Description and costs of services of other Government agencies

During fiscal year 1960 SAM will obligate a total of $55,764 for transfers of funds and interagency agreements for performance of medical research by other Government agencies to further the mission of the School of Aviation Medicine; $35,000 has been advanced to the National Bureau of Standards for the conduct of research on the physical and chemical properties of materials and equipment used in restorative dentistry. This is a continuing program and is included in the financial planning for fiscal year 1961.

Another continuing program is that being performed by the Atomic Energy Commission at Oak Ridge, Tenn., involving the maintenance and observation of gamma-irradiated burros by the University of Tennessee and the Atomic Energy Commission Agriculture Research Laboratory. This program costs $10,964 per annum and has been included in the financial plan for both fiscal year 1960 and fiscal year 1961.

The Armed Forces Institute of Pathology is performing research (supported by the School of Aviation Medicine) on the influence of reduced oxygen tension upon intermediary metabolism in an effort to relate this information to the practical study of hypoxia as a causative factor in aircraft accidents. The program cost during fiscal year 1960 is $8,800 and will require no further funding.

Other programs which were fully funded during prior years but are still underway include research on the development of simple screening procedures for the detection of volatile poisons in body fluids and tissue, by the Armed Forces Institute of Pathology and research for design and the construction of a bone conductor calibrating unit by the National Bureau of Standards, U.S. Department of Commerce.

During fiscal year 1960 the Defense Atomic Support Agency has partially financed a laboratory investigation of the production of chorioretinal injury and protection afforded by photochromic filters. This investigation is very closely related to the current in-house and contractual program of the School of Aviation Medicine. To date, DASA has provided $59,250 for support of this work.

Interagency personnel loans

The School of Aviation Medicine research program is not augmented by borrowed personnel from other Government agencies; on the other hand, there are no School of Aviation Medicine staff members on loan to other Government agencies.

Floor space

In the new quarters, which it occupies at Brooks Air Force Base, the School of Aviation Medicine comprises a total of 50 buildings with 500,300 square feet of floor space. Its principal research activities are, however, carried out in 5 new permanent structures comprising 152,900 square feet of usable floor space. There is a total of 55,500 square feet allocated for laboratory use and 69,900 square feet for direct laboratory support.

Special laboratory facilities

The following special laboratory facilities are used extensively in the research program of the School of Aviation Medicine:

(1) Audiology facilities:
  - (*a*) Anechoic chamber, 10′ x 10′.
  - (*b*) Reverberation chamber, 9′ x 11′.

(2) Environmental chamber:
  - (*a*) Altitude chamber, twin-animal; 14′ long x 6′ wide x 6′6″ high: (2).
  - (*b*) Altitude chamber, animal; 7′ long x 6′ wide x 6′6″ high: (4).
  - (*c*) Rapid decompression chamber, group; 14′ diameter x 40′ long.
  - (*d*) Altitude chamber, human; 30′ long x 8′ wide x 8′ high.
  - (*e*) Altitude and positive pressure chamber; 800 cubic feet.
  - (*f*) Portable altitude chamber; 12′6″ long x 7′ diameter.
  - (*g*) 20-man rectangular, altitude chamber; 24½′ x 8′ x 7½′.
  - (*h*) 6-man rectangular, parasite chamber; 13½′ x 6′ x 7½′.
  - (*i*) 4-man rectangular parasite chamber; 13½′ x 6′ x 7½′.
  - (*j*) 1-man space cabin simulator.
  - (*k*) 2-man space cabin simulator.
  - (*l*) Altitude and temperature chamber; 20′ long x 47′ wide x 12′ high. Type—Temperature, altitude, humidity. Limits—minus 67° F. to plus 150° F.; 10% to 90% relative humidity at ground level (through dry bulb 40° to 110° F.); ground level to 100,000 feet.

(3) Radiation facilities:
  - (*a*) Cobalt 60 irradiation facility.
  - (*b*) 260 k.v.p., deep therapy unit.
  - (*c*) Neutron generator.

Special research equipment, $25,000 or more per item

In addition, the following items of research equipment with an acquisition cost in excess of $25,000 are on hand:

(1) 14-channel magnetic recording memory unit for digital computer, acquisition cost—$50,000.
(2) Digital computer, acquisition cost—$64,307.
(3) Analog computer, acquisition cost—$90,000.

Valuation of newly constructed buildings, School of Aviation Medicine, Brooks Air Force Base, Tex.

Land, improved	$32,307.09
Storm drainage system	53,715.82
Pavements—bituminous roads	7,647.50
Parking and storage areas	59,056.69
Walks	20,879.53
Buildings, permanent, technical	6,998,819.97
Miscellaneous structures	419,261.39
Exterior water distribution systems	50,979.98
Exterior sewer system	21,511.41
Sewage treatment plants	37,594.38
Exterior overhead electric system	119,959.34
Exterior underground electric system	160,409.64
Exterior gas distribution system	12,910.71
Boiler plants	452,108.69
Incinerators	2,300.00
Communications system	46,555.61
Total of real property	8,496,017.75

Staff breakdown

	Scientific staff			Administrative and technical support staff		
	Military	Civilian	Total	Military	Civilian	Total
Doctor of Philosophy:						
Biology	1	4	5			
Psychology	2	2	4			
Physiology		8	8			
Biochemistry		2	2			
Physics	1	3	4			
Statistics		3	3			
Microbiology	1		1			
Chemistry		1	1			
Botany	1		1			
Education					1	1
Organic chemistry	1		1			
Bacteriology		3	3			
Doctor of Medicine:						
Doctor of Medicine: General	11	4	15	1		1
Flight surgeon	33	1	34	3		3
Doctor of Dental Surgery	10		10			
Doctor of Dental Medicine	2		2			
Doctor of Veterinary Medicine	6		6			
Master's degree:						
Metallurgy-chemist	1		1			
Psychology	1		1	1		1
Greek-Hebrew (ThM)				1		1
Physics	1		1			
Aeronautical engineering	1		1			
Chemistry	1	6	7		1	1
Physio-optics	2		2			
Bacteriology	1	1	2		1	1
Biology	2	1	3			
Hospital administration	1		1	1		1
Library science					1	1
Audiology	2		2			
German					1	1
Physiology				1		1
Speech		1	1			
Zoology	1	1	2			
Math		3	3			
Plant pathology	1		1			
English				1	1	2
Education				1	3	4

Staff breakdown—Continued

	Scientific staff			Administrative and technical support staff		
	Military	Civilian	Total	Military	Civilian	Total
Bachelor degrees	31	17	48	44	38	82
Subtotal	115	61	176	54	47	101
Civilian consultants (WAE):[1]						
Doctor of Medicine		2	2			
Doctor of Philosophy:						
Psychology		2	2			
Physiology		2	2			
Dentistry		1	1			
Biochemistry		1	1			
Education		1	1			
Math		1	1			
Doctor of Dental Surgery		2	2			
Subtotal		12	12			
Grand total (289)	115	73	188	54	47	101

[1] "When actually employed," pertaining to provisions for employment of consultants under the civil service system.

3. Aeromedical Field Laboratory, Air Force Missile Development Center, Holloman Air Force Base, N. Mex.

The Aeromedical Field Laboratory (AMFL) was established in 1952 for the study of human tolerance to abrupt accelerations. The current mission of the Aeromedical Field Laboratory is to develop improved techniques for human factors studies with high speed track testing procedures and instrumentation, to determine human physiological tolerance to abrupt deceleration, to develop methods and procedures for testing biosatellite capsules and components, to maintain adequately conditioned animals for all track, chamber and biosatellite test operations, and to provide pre- and post-test clinical evaluation of test animals.

Current major programs

The Aeromedical Field Laboratory is currently pursuing programs to improve techniques for physiological data acquisition, to determine relative biological effect of heavy cosmic particles, to determine tolerance to impact forces, to establish physiological base lines of research animals, to determine physiological tolerance to unusual environments, to determine capability to perform in unusual environments, and to determine biological adequacy of advanced vehicles. In addition to the above, the Laboratory has been designated the responsible DOD Agency for direction of the NASA Project Mercury animal program.

Future anticipated major programs through fiscal year 1970

(1) DYNA SOAR (an advanced experimental manned boost-glide aircraft);

(2) Supporting and applied research and testing for all manned space programs in the Air Research and Development Command Applied Research Area.

Authority for present and anticipated future programs is provided by the following approved USAF projects:

(1) Biomedical Test and Techniques for Advanced Vehicles;

(2) Biodynamics of Flight;
(3) Animal Performance in Space Environments;
(4) Support of Project Mercury;
(5) Future programs will be performed under the above listed Projects and/or as directed by Headquarters, ARDC to support present planning objectives.

Suitability of present and planned facilities

Present facilities lend themselves well to the assigned mission from the specialized experimental equipment point of view; however, the laboratory staff has outgrown the original laboratory building and has had to be housed in other buildings not designed for life sciences research and development. It is anticipated that, with a stepped up program of aerospace activities, including possible requirements for increased support of NASA's Project Mercury, some additional laboratory space will be required for the future.

Budget estimates for present and future programs

[In thousands]

	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962
BP-680 [1]	$705	$1,110	$1,635
BP-690 [2]	953	979	1,278
Total	1,658	2,089	2,913

[1] Funds for contracts and grants.
[2] Funds for laboratory operations including staff salaries, travel, etc.

Present and anticipated grants and contracts to nongovernmental groups or educational institutions

(1) No present or anticipated grants.

(2) Present and anticipated contracts for fiscal year 1960 BP–680 funds:

(*a*) Biomedical test and techniques for advanced vehicles: The objective of this project is to insure the biomedical adequacy of systems and subsystems intended for space flight, including orbital flight, through development of required testing methods, operating techniques, biophysical measuring techniques and evaluation of post mission information. Accurate knowledge of the stress characteristics of mammals is a determining factor in the selection of basic design criteria for space vehicles and for the evaluation of space flight hazards. Applied research in the biomedical aspects of aviation and space flight must provide data on survival and tolerance limits of biological specimens exposed to unusual environments such as high and low temperatures, high and low oxygen tension, high concentrations of carbon dioxide, "G" forces, isolation and motor restriction, noise, drugs, exotic fuels and other toxic substances. For fiscal year 1960 in this project area there are nine contracts, totaling approximately $417,780; in addition four additional contracts to be assigned will amount to $195,290.

(*b*) Animal performance in space environments: The objective of this project is to develop equipment for measuring animal performance during space flight and to assess animal behavior as it is affected by unusual environments. These environments will include weight-

lessness, acceleration, temperature and humidity, isolation and confinement, unusual composition of inspired air and reduced pressures, radiation and radiation prophylaxis, noise, vibration, drugs, exotic fuels and toxic substances, and other stressful environments. In this project area there are two contracts, totaling $160,096 and one anticipated contract for $40,000 for fiscal year 1960.

(*c*) Biodynamics of flight: The objective of this project is to determine the limits of uninjured survival of the human body to brief applications of mechanical force. Accurate knowledge of the dynamic stress characteristics of the human body is a determining factor in criteria for design and specifications of aircraft and space vehicles where acceleration, pulsations, impacts and pressure differentials are imposed under normal or emergency conditions of flight at any altitude. Applied research in the biodynamics of human factors in aviation and space medicine must provide data on survival and tolerance limits for the application of mechanical force to living tissue in the form of acceleration, impact (deceleration) and rapid change in total pressure (negative and positive) in the range of 10 to 6,000 cycles per second. These forces are to be investigated both in relation to area and axis of orientation. Escape systems for use during emergency conditions of flight will be tested for biological adequacy. Personal equipment will be tested for biological adequacy in varied deceleration patterns. For fiscal year 1960 in this project area there are seven contracts totaling about $398,140 and two projects yet to be assigned for $100,000.

(3) Anticipated contracts fiscal year 1961, BP–680 funds:

(*a*) Biomedical test and techniques for advanced vehicles: Continued development and improvement of test methods, equipment and operational techniques for the evaluation of astronautical systems for biomedical adequacy. The following contracts are proposed:

a. Ophthalmology, radiographs and hearing study for baseline information on subhuman primates.

b. Carbon dioxide and oxygen toxicity studies on large primates.

c. Development of a 20-channel XY physiological plotter.

d. Single and multiplace life support systems for sled testing.

e. Theoretical studies to show normal and limit ranges of physiological variables during changing body stress.

f. Development techniques to program multichannel physiological data into automatic data handling computers for analysis and easily comprehensible displays.

g. Development of radiation detection system for space vehicles.

Total amount: $705,000.

(*b*) Animal performance in space environment: Development of transistorized programing and recording equipment, behavioral reinforcement apparatus, performance parameter investigations and simulation studies. New techniques must be explored in an effort to further insure performance during certain environmental conditions. Refinement and miniaturization of standard laboratory apparatus is needed to insure behavioral measurement and minimize weight and volume requirements during actual and simulated space flight.

Total amount, $195,000.

(c) Biodynamics of flight: Continued development and improvement of specialized test equipment and instrumentation necessary to evaluate the limits of uninjured survival of the human body to brief applications of mechanical force.

Testing devices such as rocket sleds, centrifuges, abrupt deceleration devices and pressure chambers are used to investigate human tolerance limits. It is imperative that these testing devices and their supporting equipment and instrumentation maintain a state of development comparable with existing technology.

Total amount, $210,000.

Capital investment in overall plant and equipment

	Available
Aeromedical Field Laboratory facilities and equipment	1,511,000
Air Force Missile Development Center support facilities and equipment used by the Aeromedical Field Laboratory	5,727,000

Additional facilities and equipment planned directly for Aeromedical Field Laboratory total $5,252,000 by fiscal year 1970.

Support to NASA in the Mercury program has cost $147,000 in fiscal year 1960 and will probably cost a similar amount in fiscal year 1961. The Aeromedical Field Laboratory has been designated the responsible Department of Defense agency for management of the NASA Project Mercury animal program. The major objective of the program is to develop methods, techniques and procedures for determining the biomedical adequacy of the Project Mercury manned capsule. Chimpanzee's physiology, biochemistry, and performance will be studied prior to, during, and post launch. A dynamic verification of ground, flight, and recovery procedures will be made. Other space programs such as the Dyna-Soar and Discoverer will probably place requirements causing the additional expenditure of about $100,000.

Staff breakdown

	Scientific staff		Technical service		Staff total
	Military	Civilian	Military	Civilian	
	29	4	19	2	76
Doctor of Medicine:					
Flight Surgeons	2	1			
Pathologist	1	0			
Doctor of Veterinary Medicine (1 pathologist, 2 radiologists)	7	0			
Doctor of Philosophy, Psychology	1	1			
Master of Science:					
Engineering	1	1			
Physiology	2	0			
Psychology	1	0			
Chemistry	1	0			
Biology	1	0			
Medical Illustrator	0	1			
Bachelor degrees, total		19			
Equivalent BS degree, AFIT (Air Force Institute of Technology)		1			

NOTE.—Supporting personnel other than above, military and civilian by function:
Military: 1 scientific aide, 1 courier, 1 supply specialist, 2 administration clerks;
Civilian: 1 administration officer, 1 librarian, 1 mechanic, 1 supply supervisor, 1 cook, 3 animal handlers, 8 secretaries.

No personnel on loan to or from other Goverment agencies.

Major physical resources

Square feet of floor space equals 25,372.

Special laboratory facilities are Vivarium and Daisy Decelerator. The Aeromedical Field Laboratory is supported by other test facilities such as the 35,000-foot high-speed track, the stratosphere chamber, and a computation center.

Special items of research equipment

(1) Closed respiration system: Capable of sustaining life in large primates for O_2 (oxygen) toxicity studies, temperature and humidity studies, and animal performance in altered environments.

(2) Underwater decelerator tank.

(3) Rapid-cycling pressure chamber.

(4) Sonic wind blast sled 1 and 2. Sled No. 1 designed for deceleration studies up to 200 g.; sled No. 2 designed for high speed, to mach 2.

(5) Physiological data acquisition system (flight qualified) telemetry system to transmit electrocardiogram, temperature, etc., to ground station with digital and analog readout.

(6) Cosmic radiation counter: Suitable for satellite flight with capability to telemeter information on "hits" to ground station.

(7) Daisy decelerator sleds 2 and 3: Sled No. 2 designed to study impact forces (animals only). Sled No. 3 designed to study impact forces, forward and rear facing (human).

(8) Lockheed sled: Lightweight, high speed, small payload for use with high-speed track.

4. PERSONNEL LABORATORY, DIRECTORATE OF ADVANCED SYSTEMS TECHNOLOGY, WRIGHT AIR DEVELOPMENT DIVISION, LACKLAND AIR FORCE BASE, TEX.

The Personnel Laboratory has a continuous history with the Psychological Research Units established early in World War II in the Army Air Forces for the purpose of selecting and classifying aircrews. It continued under Air Training Command with the added function of classifying enlisted personnel; under the Human Resources Research Center of the Air Training Command with an expanded mission; under the Air Force Personnel and Training Research Center of the Air Research and Development Command; and in its present status since January 1, 1958.

The mission of the Personnel Laboratory is to conduct research and development in support of the operation and qualitative improvement of the Air Force Personnel System. This includes the development and evaluation of concepts and techniques concerned with the functional areas of personnel requirements, procurement, classification, training assignment, utilization, proficiency measurement, promotion, retention, separation, and accounting.

Current major programs

(1) Occupational analysis: Planning and conducting psychological research on occupational analysis of Air Force jobs and on allied problems in order to increase the effectiveness of personnel utilization through improved position and qualification analysis and job definition.

(2) Airman proficiency tests: Conducting research and development to insure the production, administration, and analysis of Airman Proficiency Tests and Air Force Job Knowledge Tests; monitoring the airman proficiency testing program.

(3) Adaptability, quality, and personnel evaluation research: Conducting research and development on the assessment and prediction of adaptability to Air Force life, including the identification, measurement, and evaluation of motivation, morale, aptitudinal, situational, and personal factors as they relate to personnel utilization, retention, and performance.

(4) Selection and classification: Planning and conducting psychological research for the purpose of development of and/or improvement of selection, classification, and evaluation devices for Air Force personnel.

(5) Statistical methodology: Accomplishing research in statistical, mathematical, and computational methodology with emphasis on application of these techniques to psychological research.

Future anticipated major programs through fiscal year 1970.

Future programs through fiscal year 1970 are expected to be in the same general areas specified above:

(1) The occupational analysis research program is in its initial stages. It is expected to progress rapidly in the areas of position analysis, work systems analysis, and qualifications analysis.

(2) The airman proficiency test development program is primarily an operational support activity and is programed for continuation in essentially its present pattern, adjusting as needed to changes in Air Force job structures.

(3) Adaptability and quality evaluation research has made progress in identifying personnel least adaptable to Air Force requirements, and plans call for a relative increase in efforts in this area.

(4) Selection and classification research and development is a well-established program. Efforts between now and fiscal year 1970 will be devoted to keeping current with Air Force needs, including the development of new measures and measures in new areas as required.

(5) Developments in statistical methodology are programed in the areas of mathematical models and simulation of personnel systems as management tools, as well as improved, high-speed personnel research statistics.

Authority for present and anticipated programs

(1) Authority for current and programed research and development lies in the following Headquarters, USAF-directed, ARDC-approved projects:

(*a*) Operational Selection and Classification Tests for Air Force Personnel;

(*b*) Development of Procedures for Selection, Classification, Retention, and Utilization of Personnel;

(*c*) Development of Methods for Describing, Evaluating, and Structuring Air Force Occupations.

(2) In addition, various Headquarters, USAF regulations and manuals direct the Personnel Laboratory to accomplish portions of the research and development activities required in the above-cited projects.

Suitability of present and planned facilities to current and assumed future missions through fiscal year 1970

Present and planned facilities are deemed to be adequate through fiscal year 1970 for the mission of the laboratory as currently programed.

Possible mission of personnel laboratory in support of life science research requirements

(1) To a great extent personnel technical developments for which AMFL is presently responsible, and which provide direct support to various system requirements for missiles and space vehicles, are not peculiar to specific systems. Certain developments may be relevant to specific subsystems common to several systems; e.g., knowing the aptitude requirements for proper maintenance of an electronic subsystem of one missile will permit reasonable prediction of the aptitude requirements of a future missile or space system using similar electronic gear. Other developments may be relevant to operational use of more than one planned system. For example, technical development in the areas of motivation and morale of personnel working in deprived and limited environments will be applicable across many systems. Similarly, the inclusion of missile systems just coming into being in our occupational analysis development activities should yield improved techniques which can be utilized by personnel responsible for establishing qualitative personnel requirements procedures. In brief, by working with missile systems just becoming operational the laboratory will provide the kinds of projections needed for future missile and space vehicles. Specific possible programs for the immediate future are described below.

(2) Aptitude requirements: (*a*) Continued study is necessary to determine whether any aptitudes not currently measured by Air Force tests will be required in either the maintenance or operation of any missile, or whether certain aptitudes become much more important. Just as the present pilot stanine has somewhat different characteristics from the World War II pilot stanine, the missile maintenance and operator aptitude requirements may well have special characteristics. These characteristics cannot initially be forecast with accuracy. By working with systems soon to be operational, the estimation of requirements for future systems can be greatly improved.

(*b*) The necessity for investigation of the aptitudinal characteristics of personnel associated with the new systems is highlighted by a review of previous QPRI (qualitative personnel requirements) materials. Factual bases for assignment of minimum aptitude levels for certain jobs did not exist at the time the levels were recommended; assigned levels were educated guesses. There is a natural tendency to specify a higher level of aptitude than may actually be required, because the penalty for error is severe. As experience with a system grows the judgment of workers intimately associated with such weapons becomes more objective and realistic, but the percolation of such information through the Air Force personnel system is slow. The establishment of proper minimum levels can be accelerated through planned investigation of the aptitude characteristics and job-adequacy of incumbent personnel. It is quite important that the minimum aptitude levels appropriate for such weapon systems positions be established objectively and early if

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the most efficient use of personnel is to be made. The complex equation of equipment design suitable for operation by persons of the aptitude characteristics of the average Air Force enlisted man or officer, after a training period that does not exceed economic limits of time, materiel, and money, can only be solved by intensive investigation of the currently "operational" situation.

(3) Motivation, morale, and productivity: (*a*) The geographical isolation and austere living conditions associated with some missile sites, the necessity for long duty tours within this type of environment, the routine tasks that will be called for in maintaining equipment, the work shifts, and proximity to explosive or highly flammable materials provide a potential source for morale and retention problems among missile personnel. There are several approaches to the reduction of these problems:

1. Differential selection procedures: The selection of career personnel most likely to adjust to conditions associated with missile environments represents one of the most promising approaches to the morale problem. Past research in personnel retention, as well as research on adjustment to isolated sites among Air Control and Warning System and Airways and Air Communications Service personnel indicates that it may be possible to develop a device to optimize retainability, productivity, and high morale among missile personnel through the selection of individuals for assignment to missile training.

2. Unit assembly procedures: The formation of groups for compatability becomes particularly crucial among individuals assigned together for long periods of time in deprived areas. The research literature suggests that some of the parameters for group adjustment and morale are known. It would appear worthwhile to gain increased knowledge of characteristics relating to group adjustment, and to determine the possibility of organizing groups to maximize morale.

3. Orientation procedures: The preparation that personnel receive prior to assignments should be related to later adjustment and morale. Indoctrination may include such considerations as effective use of leisure time, techniques for reducing discomfort induced by severe conditions, developing espirit de corps, and the feeling of doing something important in the national interest. Research would permit experimental evaluations of indoctrination methods as techniques for increasing morale among isolated personnel.

4. Organizational or administrative procedures: A considerable body of knowledge is available concerning leadership, organizational, and administrative factors as they affect morale at socially and geographically deprived locations. While new development efforts do not appear to be called for at this time, there is a need to organize relevant information obtained from Strategic Air Command, Air Defense Command, and Military Air Transport Service in their experiences with units located at geographically remote stations.

(*b*) Possible developments include the following:

1. In the development of selection devices, the first step would consist of identifying the major factors associated with reten-

tion, morale, and productivity, among groups stationed at geographically isolated sites. The second step would involve the development of tests (biographical, interest, or attitude) measuring the attributes found relevant for morale productivity, and retention at isolated sites. This would be followed by the collection of test data for personnel presently stationed at isolated sites, in the missile-training pipeline, and in the population reservoirs from which missile trainees will be selected. Validation of the tests developed would occur as retention, performance, and morale criteria are collected over time.

2. Sociometric data collected in conjunction with morale and retention research conducted at isolated sites (see sub paragraph above) would be analyzed to determine the characteristics associated with group acceptability and rejection. Additional studies involving unit assembly could be initiated dependent on the successful identification of the characteristics described above.

3. Orientation techniques could be initially studied using groups of basic trainees. Willingness to volunteer for isolated duty might serve as a criterion for evaluation of different methods.

4. A review of the literature, and additional information from Air Force commands who have faced organizational and administrative problems in isolated sites would be accomplished. This would provide useful information for commanders of new units.

(4) Occupational analysis developments: (*a*) The Laboratory program in occupational analysis can be applied to the space and missile area by including missile positions in some studies now being initiated. An example is the development of occupational analysis information from characteristics of equipment. This study could concentrate on existing missile systems to provide a systematic basis for describing equipment oriented work activity. Findings should have inputs to QPRI activities in the missile area.

(*b*) Other programed studies can integrate the collection of data from the training and practice bases set up for the Snark, Atlas, Titan, and Thor missiles. These are: (1) development of standardized procedures for establishing lists of critical Air Force jobs for qualifications studies; (2) development of procedures for inferring qualifications needed for performing specific Air Force jobs; (3) development of standardized methods of providing job requirements information by inference from the characteristics of successful incumbents; and (4) development of standardized followup techniques to determine the effectiveness of qualifications recommendations. This program would consist of observation of missile maintenance and operational launch practices aimed at identifying positions which contain tasks requiring uncommon or critical qualifications; and would be implemented and extended by establishing methods for discovering such qualifications from the tasks performed, both as stated in appropriate documents and as actually observed. The program would involve analysis of the capabilities, training, and experience of incumbents to determine whether the assumed requirements of tasks are real and would interrelate these findings with career progression.

(5) Other technical development activities with implications for future space systems: (*a*) Information on aptitude distributions in the

present Air Force population and especially those who plan to make a career of the service, by Air Force Specialty Code, will be useful in weapons system development.

(*b*) Information on the relationship of Air Force aptitude indices to civilian tests and norms, and to civilian jobs and job levels, will be particularly valuable to Air Force contractors concerned with designing equipment for optimal operation and maintenance.

(*c*) information on trends in aptitudes and education of future airmen is essential for system planning. The knowledge and skills brought to service by incoming airmen may be exploited only by training based on these skills. This area divides into three phases so far as research is concerned. First is an assessment of the degree to which possession of certain educational skills enhance success in current training programs; second is the determination of the proportions of incoming airmen who will possess such academic training; third, the charting of the aptitudes which will be held by the incoming group will be of importance in the design of systems as well as in the establishment of curricula in the schools.

(6) Summary statement: The preceding paragraphs outline a possible long range program for the Personnel Laboratory in support of future missile and space systems. It will have been apparent that personnel system development in support of future weapons is achieved through investigation of current systems and those just becoming operational. The outcomes of these investigations are projections, estimates, and tentative procedures which are applied to newer systems, tested on them, and refined for application to still newer weapons systems. Through this series of successive approximations the Laboratory could provide personnel system support for the advanced weapons now in early planning stages.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–62)

	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962
P690: [1]			
Civilian personnel	$884,000	$863,200	$863,200
TDY Travel	25,000	25,000	25,000
Supplies and equipment	48,200	57,000	57,000
Miscellaneous contracts	9,000	10,000	10,000
EDPS rental	297,214	303,757	412,400
Modification of equipment		6,000	
Major repair and rehabilitation		63,600	
Printing and reproduction	5,000	5,000	5,000
Office machine rental	5,370	4,050	4,050
Others	4,000	4,910	4,910
Total P690	1,277,784	1,342,517	1,381,560
P680 [2]	450,000	450,000	450,000
Total P690 and P680	1,727,784	1,792,517	1,831,560

[1] P-690—maintenance and operations funds, including pay of laboratory staff, travel, etc.
[2] P-680—funds for contracts and grants.

Contracts to nongovernmental groups or educational institutions

[In thousands]

	1960	1961	1962
(1) Operational Support Development	$100	$100	$100
(2) Applied Research	350	350	350
Total	450	450	450

Capital investment in overall plans and equipment, both at present and anticipated for future years to fiscal year 1970

(1) Building for laboratory: $432,745 (present).
(2) Property and equipment: $347,152 (present).
(3) Records archives, approximately 18,000 square feet, permanent: $281,000 (proposed).

Present and anticipated services to other Government agencies for performances or performed at in-house facilities for other Government agencies

None.

Staff breakdown

(1) Scientific staff	69
Technical services	113
Total	182
(a) Scientific staff:	
Military	18
Civilian	51
Total	69
(b) Technical services staff:	
Military	37
Civilian	76
Total	113
(2) Education:	
(a) Doctor of philosophy:	
Psychology	25
Education	2
Mathematics	1
Total	28
(b) Master's degree:	
Psychology	18
Social science	1
Mathematics	1
Sociology	2
Education	3
Administrative education	1
Total	26
(c) Bachelor's degree:	
Psychology	9
Mathematics	2
Chemistry	1
Physics	2
Accounting	1
Military science	1
Business administration	1
Mathematical education	1
Total	18

Support personnel

	Civilians	Officers	Airmen
Administration	1	1	1
Mail and records	1		1
Personnel	2		2
Supply	1		2
Printing	6		2
Total	11	1	8

Personnel on loan to other Government agencies

(1) Number: Three.

(2) Type: 1 civilian psychologist; 1 officer (Capt., psychologist); 1 airman (T/Sgt.).

(3) Education Psychology and Aptitude Test Development Team on temporary duty to the Military Assistance Advisory Group, Tokyo, Japan, to study the present Japanese Air Self Defense Force (JASDF) testing program and to assist JASDF personnel in developing adequate tests to measure such factors as ability, aptitude, perception, achievement, motivation, and personality within JASDF.

(4) Reason: Directive from Hq USAF.

Major physical resources

(*a*) Square feet of floor space:

(1) Laboratory: 49,889 square feet.

(2) Records archives: 19,916 square feet.

(3) Airmen barracks (2): 12,880 square feet each, for total of 25,760 square feet.

(*b*) Special laboratory facilities:

(1) Dormitory space for fifty (50) subject matter specialists on temporary duty at the Laboratory at regular intervals.

(2) Test rooms (2) for experimental testing, total of 4,642 square feet.

(3) Records archives for storage of test materials.

(c) Special items of research equipment ($25,000 or more per item):

(1) Analog computer equipment: $34,141.

(2) (See paragraph above for EAM equipment.)

5. Life Sciences Directorate, Air Force Office of Scientific Research, Air Force Research Division, Washington, D.C.

The Life Sciences Directorate of the Air Force Office of Scientific Research was established in the spring of 1956. It has contained from its origin two divisions: One, the Biological Sciences Division, was formerly called the Aeromedical Division, and two, the Behavioral Sciences Division. The Directorate of Life Sciences has as its mission the development of knowledge which will be useful to the Air Force in the field of improved human performance, and through the application of biological knowledge to the development of better Air Force systems.

The purpose of life sciences research is to develop knowledge which will permit identification, analysis and prediction with regard to those aspects of human nature and behavior which are

critical to the effective use of human operators in the Air Force now and in future air and space assignments. The frontiers of knowledge in the disciplines of physiology, biochemistry, pharmacology and other biological specialities and in the fields of psychology, anthropology, sociology, and psychiatry, are explored to produce information vital to the solution of Air Force human factors problems.

This effort should provide fundamental knowledge, concepts, theories, and methodologies applicable to the integration of human beings into increasingly complex Air Force vehicles and systems. It should permit the improved organization and performance of crews and work units. It should provide for the continuing advancement of human performance in intellectual and nonintellectual roles. It should provide information which will facilitate the design of superior Air Force systems through a better understanding of the human capacities and limits. Finally, it should provide improved knowledge of environments in which Air Force personnel will operate including normal working environments and those characterized by the stresses of space flight, requirements for extended monitoring of equipment, and an understanding of the degradation of human performance over time due to the influence of all relevant factors.

Current major programs

(1) Biological Sciences Division:
  (*a*) Brain mechanisms.
  (*b*) Environmental tolerance.
  (*c*) Molecular biology.
  (*d*) Communications biophysics.
  (*e*) Biosynthetic mechanisms.
(2) Behavioral Sciences Division:
  (*a*) Behavioral aspects of man-machine systems.
  (*b*) Research on crew and unit organization and performance.
  (*c*) Psychological factors in human performance.
  (*d*) Research on environmental and occupational stress.
  (*e*) Research on AF intelligence personnel responsibilities.
  (*f*) Research on models for computer analysis of human factor problems.

Future anticipated major problems through fiscal year 1970

In the area of biological sciences, it is anticipated that the program will be expanded to include studies in the following areas: Central nervous control of cardiovascular response, animal orientation and navigation, temperature regulation, biochemical genetics.

In the behavioral sciences, it is believed that current tasks are of sufficient breadth to permit expansion and extension to cover all areas of basic research interest of the Air Force through fiscal year 1970. Areas which should receive added attention are those concerned with the use of modern cybernetic equipment to program complex operations involving simulation, testing and evaluation through computerized systems or models of systems.

Authority for present and anticipated future programs

Air Research and Development Command Research Planning Objective for Biosciences, dated July 1958.

Suitability of present and planned facilities to the current and assumed future missions through fiscal 1970

Current—adequate.
Future—good.

Roles other than astronautics which organization could perform in meeting life sciences research requirements of the armed services

Since mission is basic research, the product has servicewide utility.

FISCAL DATA

Budget estimates for present and future programs (fiscal years 1960–62)

Biosciences Division:	
Fiscal year 1960	$1,030,000
Fiscal year 1961	960,000
Fiscal year 1962	1,650,000
Behavioral Sciences Division:	
Fiscal year 1960	960,000
Fiscal year 1961	1,050,000
Fiscal year 1962	1,365,000

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories

(*1*) *Biological Sciences Division*

(*a*) Brain mechanisms: The objective of this task is to understand better the intricate neural and humoral integrating mechanisms that form the basis for human behavior and performance and are intimately involved in the adjustment that man must make to unusual environments. Current annual cost: $295,000.

(*b*) Environmental tolerance: The objective of this task is to further fundamental knowledge of the physiological and biochemical characteristics of those aspects of the human organism that are critically stressed by the physical and social environment of Air Force operations. Current annual cost: $385,000.

(*c*) Molecular biology: The objective of this task is to support a program of fundamental research on those aspects of molecular and cellular biology which are basic to understanding the critical problems in man's psychological and physiological adjustments. Current annual cost: $200,000.

(*d*) Communications biophysics: The objective of this task is to analyze the sensory, communication and transmission aspects of biological systems by the techniques of anatomy, physiology, physics, mathematics, and psychology in order to discover unique principles in their operation which may be applicable to communication and computer engineering. Current annual cost: $85,000.

(*e*) Biosynthetic mechanisms: To elucidate the processes by which complex and energy-rich substances are synthesized by plants and animals; to understand the control mechanisms responsible for the remarkable specificity and efficiency of these syntheses; and to exploit such techniques for laboratory or large-scale production of these or similar compounds. Current annual cost: $85,000.

(*2*) *Behavioral Sciences Division*

(*a*) Behavioral aspects of man-machine systems: Research to provide basic knowledge concerning the man-machine interactive proc-

ess, with special reference to the proper design, development and effective use of complex man-machine Air Force weapon and space systems. Current annual cost: $150,000.

(*b*) Crew and unit organization and performance: Investigation of interpersonal factors affecting the selection, leadership, morale and effective performance of crews and units in strange ground or aerospace environments. Current annual cost: $250,000.

(*c*) Phychological factors in human performance: Research to create new techniques for sustaining and improving the performance of Air Force personnel in coping with increasingly complex weapons and equipment operated in unusual situations. Current annual cost: $300,000.

(*d*) Research on environmental and occupational stress: Provide an understanding of the effects of specific environmental stresses such as isolation, sensory deprivation, and restricted personal contacts upon duty performance. Current annual cost: $100,000.

(*e*) Air Force intelligence personnel responsibilities: Discovery of new techniques for effective use of personnel in the collection and analysis of information and the protection of personnel against enemy subversion. Current annual cost: $100,000.

(*f*) Models for computer analysis of human factor problems: Basic knowledge in the behavioral sciences in the area of the rapid and reliable measurement and prediction of the reaction of foreign peoples to air weapon development and other Air Force activities. Current annual cost: $75,000.

Capital investment in overall plant and equipment, both at present and anticipated for future years through fiscal year 1970: None.

Description and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies for fiscal year 1960 and fiscal year 1961: None.

Staff breakdown

	Scientific staff		Technical service		Total
	Military	Civilian	Military	Civilian	
Total	2	4	0	2	8
Doctor of Philosophy:					
Biology		1			
Psychology	1				
Biochemistry		1			
Sociology		1			
Social psychology		1			
Doctor of Medicine: Radiobiology	1				
Total: 6 staff scientists at doctorate level.					

Number and types of personnel on loan to other Government agencies or on loan from other Government agencies

None.

Major physical resources

Square feet of floor space: 1,500 square feet.

Special laboratory facilities: None.

Special items of research equipment: None.

6. Biophysics Division, Research Directorate, Air Force Special Weapons Center, Kirtland Air Force Base, N. Mex.

The Biophysics Division was organized at the Air Force Special Weapons Center, Kirtland Air Force Base, N. Mex., in September 1954 and assigned to the Research Directorate. The mission of the Biophysics Division is to determine the effects of ionizing radiation on personnel and develop a philosophy of operation so that the Air Force can remain operational in spite of a nuclear environment.

Current major programs

(1) Delineate personnel hazards associated with reactors such as ANP (aircraft nuclear propulsion project), SNAP (systems for nuclear auxiliary power), ROVER (nuclear powered rocket project), PLUTO (nuclear powered ramjet project—same as USAF project SLAM); and design appropriate countermeasures to insure safe operations.

(2) Investigate personnel hazards from ionizing radiations in ambient space and recommend a philosophy of operation to insure bioastronautical safety.

(3) Continue research of nuclear weapon effects for interpretation of personnel hazards from close-in operations, plutonium inhalation, tritium dispersion and uptake, peacetime nuclear weapons accidents, neutron detection, relative biological effects of ionizing radiations, remote decontamination of large land areas, low-level strataspheric contamination, free-field radiation behavior, neuropsychological effects of irradiation, rate of biological recovery from ionizing radiations, and such other radiation experiments with biological specimens and plastic manikins as necessary to extrapolate to man the hazards associated with nuclear weapon operations.

(4) Perform such research, development, and evaluation as is necessary to standardize radiac instrumentation for the USAF use in operational and laboratory research situations.

Future anticipated major programs through fiscal year 1970

(1) Nuclear propulsion systems envisioned for Air Force application are now all in the developmental stage and will not become operational for some years in the future. A continuing hazard evaluation of each system will be required in order to permit a realistic evaluation of adequate safety procedures and accident countermeasure techniques appropriate to each phase in the system's development. Such a program will involve assessment of hazards during test phases, during preoperational testing of system prototypes, and for the fully developed system itself and will extend well beyond 1970. When the number and variety of systems are considered and the reappraisals that modifications in design will demand, this program is conceived as a continuing one.

(2) Determination of the radiation hazards of the space environment with emphasis on accurate measurements of radiation doses in human phantom simulators. The proposed program in this area is to launch tissue-equivalent plastic ionizing radiation detectors in programed flights into the higher altitudes and ultimately into space. Presently the Division working on balloon flights to 145,000 feet, Discoverer satellites in a north-south orbit, Atlas piggyback flights,

and high-altitude sounding rockets into and beyond the Van Allen Belts. With added time and experience, it is planned to graduate from simple ionization chambers into full-sized tissue-equivalent plastic manikins complete with organs and skeleton. The realization of suitable solutions to these existing problems will carry well beyond fiscal year 1970.

(3) Investigations of the biomedical effects of nuclear weapons: By no stretch of the imagination have all problems associated with the use of nuclear weapons been solved, nor will they be in the next 10 years. With the declared moratorium in existence, laboratory methods of stimulating nuclear weapon radiation phenomena must be explored so that the many unsolved problems of nuclear weapons effects on man may be studied. As man progresses to ever higher altitudes and into space, the known radiation hazards from nuclear weapon detonations in the sensible atmosphere again become unknown. Little is known of weapon phenomenology as a function of altitude in the higher altitudes, subspace, and space. Simulated weapon detonation under essentially vacuum conditions must be explored. To define these problems and effect solutions that will support Air Force operations in these environments will require a concerted effort through fiscal year 1970.

(4) There can be no end to radiac instrumentation development within the next 10 years. As new environments are explored, so must innovations be made to our existing radiac instrumentation. The biggest radiation problem in the immediate future is in neutron dosimetry. This problem promises to be paramount until fiscal year 1965. By then, the Air Force may be routinely operating above the sensible atmosphere and solar radiation will invoke new problems in radiation detection, and measurement. To fully understand these radiations and their effect on man, new instrumentation or exotic changes to existing instruments will be the order of the day. These problems conceivably will be of considerable magnitude through fiscal year 1970.

Authority for present and anticipated future programs of the biophysics division

All projects currently in progress are based on USAF requirements and are approved by Headquarters, Air Research and Development Command. Anticipated future projects are based on existing as well predicted AF requirements.

Suitability of present and planned facilities to the current and assumed future missions of this organization through fiscal year 1970

In general, the existing and planned facilities are adequate for the assumed program for the future. Already the shift in emphasis from nuclear weapons to nuclear propulsion systems and bioastronautical investigations has been felt. As the emphasis continues to change existing facilities will be realined accordingly. Programed in fiscal year 1962 is a Whole Body Counting Facility. Whole body spectroanalyses can then be carried out for the first time within the Air Force. In the embryo stage at this time is a plan to build a facility to undertake long-term animal experiments on inhalation hazards from mixed fission products. These experiments would be geared primarily to reactor operations. The program will not get underway before fiscal year 1963 and the experimentation will run

at least until fiscal year 1978. Since weapon simulation techniques must be further refined if additional information is to be gained during the moratorium, means of simulation must be investigated for establishing a program to build these simulation techniques into reality. The first area of concern is high altitude effects data, either with balloons with a test reactor, or a test reactor in an evacuated chamber. Other than these proposed facilities existing facilities are adequate.

FISCAL DATA

Budget estimates for present and future programs

During fiscal year 1960 contractual effort conducted under Division direction or guidance will amount to $745,000. Fscal year 1961 anticipates that this figure will approach $1.5 million because of increased effort on reactor hazards, bioastronautical investigations, and a specific weapon-burning test to be conducted with $300,000 of Defense Atomic Support Agency funds. In fiscal year 1962 the proposed contract budget is $1.2 million. The funds for laboratory operation, including staff salaries, travel, etc., programed for fiscal year 1960 are $210,000 with an increase to $322,000 for fiscal year 1961 and a drop to $308,000 for fiscal year 1962. The Whole Body Counting Facility has been programed for fiscal year 1962 at a cost of $180,000 military construction program funds.

Costs of present and anticipated grants and contracts to non-governmental groups or educational institutions by major categories of research

No grants will be given to any non-Government groups or educational institutions.

Contract funds

Program area	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962
1. Reactor hazards and control measures	$378,000	$542,000	$600,000
2. Nuclear radiation hazards	65,000	250,500	200,000
3. Ionizing radiation hazards to personnel	39,000	110,000	100,000
4. Personnel hazards from ambient space radiation	100,000	175,000	175,000
Total	582,000	1,077,500	1,075,000

Capital investment in overall plant and equipment

	Facilities	Equipment
Present	$247,000	$432,000
Fiscal year 1963	497,000	700,000
Fiscal year 1965	1 700,000	900,000
Fiscal year 1970	1,700,000	900,000

Description and costs of present and anticipated future services of project awards to other Government agencies for performance or performed at in-house facilities for other Government agencies for fiscal year 1960 and fiscal year 1961

(1) Biophysics work to other Government agencies (Atomic Energy Commission):

Fiscal year 1960	$157,381
Fiscal year 1961	84,000

(2) Work done for other in-house (Atomic Energy Commission):

Fiscal year 1960	5,500
Fiscal year 1961	6,000

Staff breakdown

Degree and specialty	Scientific staff		Technical services		Total
	Military	Civilian	Military	Civilian	
Doctor of philosophy:					
Electrical engineering	1				1
Chemistry	1				1
Nuclear chemistry	1				1
Radiological biochemistry		1			1
Doctor of medicine:					
Flight surgeon	2				2
Doctor	1				1
Doctor of veterinary medicine: Veterinarians	2				2
Master of science:					
Nuclear chemistry	1				1
Chemical engineering	1				1
Physics	4				4
Nuclear engineering	6				6
Mathematics	1				1
Radiological biochemistry	1				1
Bachelor of science: Total	11	1	3	1	16
Support:					
Technical			1	1	2
Administrative			2		2
Secretarial				5	5
Total	33	2	6	7	48

Number and types of personnel on loan to other Government agencies on loan from other Government agencies

None.

Major physical resources

Square feet of floor space: 8,200.

Special laboratory facilities: Irradiation Effects Laboratory on 70 acres of pasture land.

Special items of research equipment greater than $25,000 per item: Complete 256-channel-pulse-height analyzer, $50,000.

7. Operational Applications Laboratory, Air Force Command and Control Development Division, L. G. Hanscom Field, Mass.

The Operational Applications Laboratory had its origin in the aviation psychology program of World War II. Immediately following the war, the Laboratory was assigned to the Strategic Air Command, Andrews Air Force Base, to study special requirements of the Command. In 1948, the Laboratory was assigned to Headquarters Command, Bolling Air Force Base, and was designated as the Human

Resources Research Laboratories. In 1952 the Laboratory was transferred to the Air Research and Development Command and its designation was changed to Human Factors Operations Research Laboratory. With the establishment of the Air Force Personnel and Training Research Center in January 1954, the Laboratory was again reorganized. That part of the Laboratory concerned with personnel research was transferred to Air Force Personnel and Training Research Center, Lackland AFB, Tex., and the remainder of the Laboratory, concerned primarily with Air Force communications, information processing, equipment human engineering and systems analysis was transferred to the Air Force Cambridge Research Center. With this reorganization, the Laboratory was designated the Operational Applications Laboratory.

On April 1, 1960, the Laboratory was transferred from the Air Force Cambridge Research Center to the Air Force Command and Control Development Division, AFCCDD.

The current mission statement of the Laboratory reads as follows:

> Applies human engineering techniques to improve the design, performance, and operator capability of weapons and support equipment and systems developed by the Air Force Cambridge Research Center. Conducts supporting research to advance knowledge in the human engineering field.

Current programs

Current major programs of the Laboratory are as follows:

System support.—The Laboratory provides extensive human engineering support to the systems listed below. This support includes the monitorship of approximately 20 contracts as well as in-house research and development activities, such as R. & D. subsystem testing, equipment evaluation, laboratory research to improve the state-of-the-art, etc.

(*a*) Continental aircraft control and warning system (SAGE).
(*b*) Tactical air control system (TACS).
(*c*) Emergency mission support (TRACALS).
(*d*) Weather observing and forecasting system.
(*e*) Space track.

Operational support.—A limited operational support program is maintained under project: Simplified international aeronautical language. The objective of this program is the development of a simplified aeronautical language for essential air-air and air-ground radio-telephone voice communication. The need for this simplified international aeronautical language stems from the difficulties that accrue in carrying out combined military air operations with a many language group such as with the United Nations Force in Korea, NATO, and SEATO.

Technical development.—An extensive technical development program of in-house and contractor laboratory research is carried out by the Laboratory. This effort is primarily in the area of human performance but also includes a broad program of research in the area of surveillance techniques. Objectives of this program include, but are not limited to, advancing knowledge in the human engineering field and determining human capabilities and limitations under a

wide range of operational conditions. The following projects make up the technical development program of the Laboratory:

(*a*) Surveillance Techniques:

(1) Threat Evaluation and Action Selection.

(2) Data Processing Techniques for Recognition and Identification.

(*b*) Human Performance (Program Area 780E):

(1) Information Processing by the Human Operator.

(2) Communication in Noise.

(3) Information Transmission Thru Visual Displays.

(4) Operational Applications of System Integration Principles (Man-Machine Interface).

(5) Automated Instruction-Teaching Machines for On-the-Job Training.

(6) Computer-Man Relationships in Information-Processing Command and Control Systems.

(*c*) System Support: (1) Human Factors for the Weather Observing and Forecasting System.

(*d*) Aerospace Environment: (1) Human Engineering of Meteorological Displays.

Basic research

The program of the Laboratory in the basic research area (Program Area, Biosciences) is at present limited in scope due primarily to the lack of funds during prior years. It is anticipated that with increased funds programed for the next fiscal year, this program will be given increased impetus. The program includes laboratory research in-house and under contract with universities. The current program consists of the following two projects:

(*a*) Research on Psychophysiology of Information Processing.

(*b*) Research on Parameters in Visual Perception.

Future program

It is anticipated that the major programs of the Laboratory through fiscal year 1970 will be developed along the following lines:

1. Continuation and expansion of the current technical development program with increased emphasis in the area of human performance.

2. Continuation of human engineering support to systems now being supported by the Laboratory and establishment of support to other systems under development by the Air Force Command and Control Development Division (AFCCDD).

3. Development of a technical program in support of the applied research objectives assigned to AFCCDD in accordance with the program objectives currently projected through 1970.

Authority

Authority for the research and system support programs of the Operational Applications Laboratory is contained in the following documents, directives, and regulations.

1. The Current Operational Applications Laboratory mission statement in support of AFCRC.

2. Air Force Regulation 80–28, Mockup Boards and AFR 80–14, Testing and Evaluation in Support of Operational and Technical Programs and Engineering Services.

3. Joint ARDC-Air Training Command Directive on Personnel Subsystem Management.

4. Program objectives assigned to AFCCDD which set forth the mission of the Laboratory in Research and Development Psychology in support of AFCCDD.

Facilities

Present facilities are suitable for current mission. Requirements for expanded facilities will be coordinated through AFCCDD.

Mission in support of astronautics

The mission of the Laboratory in direct support of AFCCDD does include some indirect implications for astronautics. Accordingly, this mission is completely compatible with life sciences research and development requirements of the armed services.

FISCAL DATA

Budget estimates

Budget estimates for fiscal years 1960–62 are shown below. These estimates are broken out into the two major budget categories (i.e. BP 610/680——Contract funds and BP 690—Operations and Maintenance funds) under which the Laboratory is funded. These estimates are further broken out into a budget authorization column, which reflects the actual B/A for fiscal year 1960 and the imposed ceiling amounts for fiscal years 1961–62. The BP 690 category includes Personal Services funds as well as all other BP 690 funds (e.g. travel, supplies, equipment, etc.).

Amounts shown in the fiscal year 1960 BP 610/680 category reflect funds allocated directly to the Laboratory by higher headquarters as well as funds provided to the Laboratory by the Systems Office of primary mission responsibility for systems supported by the Laboratory. Since these funds are provided on separate obligation authorities for each separate contractual action at the time the contractual action is initiated, it is not possible to include fiscal years 1961–62 B/A amounts for these efforts. Thus the amounts shown in the B/A column for fiscal years 1961–62 reflect only funds allocated directly to the Laboratory by higher headquarters. However, it is anticipated that the fiscal year 1961–62 allocations will be approximately the same as the amount shown for fiscal year 1960.

Budget estimates

	BP 610/680 B/A	BP 690 B/A	Total B/A
Fiscal year 1960	$954,000	$367,000	$1,321,000
Fiscal year 1961	362,000	345,000	707,000
Fiscal year 1962	362,000	345,000	707,000
Total	1,678,000	1,057,000	2,735,000

Grants and contracts

This Laboratory neither has nor anticipates grants to either nongovernmental groups or educational institutions. Contracts are with educational institutions, private research organizations, and civilian industry. The level of the current contractual effort is shown below by major categories of research. It is anticipated that the level of this effort will be increased during each of the next several fiscal years; however, due to current funding limitations and ceiling amounts imposed for fiscal years 1961 and 1962, the magnitude of this increase is not firm.

Amounts shown below reflect fiscal year 1959 as well as fiscal year 1960 commitments and obligations. The fiscal year 1959 amounts are shown for the reason that many of the contracts negotiated during fiscal year 1959 are still in effect. Thus the current program consists of commitments and obligations made during each of the 2 fiscal years. Amounts are not shown for contracts negotiated in fiscal year 1959 but which have terminated and for which fiscal year 1960 funds are not available to effect an extension of the contract.

(*a*) System support	$510,000
(*b*) Technical development	780,000
(*c*) Operational support	(1)
(*d*) Basic research	60,000
Total	1,350,000

[1] No fiscal year 1960 funds available.

Equipment

The value of equipment now on hand in the Laboratory is estimated at $250,000.

Requirements have been shown for equipment funds in the amount of $100,000 for fiscal years 1961 and 1962. It is anticipated that funds in the amount of $50,000 will be required for equipment for each fiscal year through fiscal year 1970.

Other governmental agencies

This Laboratory neither has nor anticipates awards, contracts, projects, etc., with other governmental agencies.

Major physical resources

Floor space: Square feet of floor space is as follows:

1. Laboratory space	3,600
2. Office space	5,000
Total	8,600

Special laboratory facilities: The Laboratory area includes one medium size anechoic chamber of internal dimensions of 8 feet by 16 feet in area and 6 feet 4 inches in height. There are also available nine experimental chambers of various sizes, all of which are soundproof, lightproof, and radio shielded. These facilities occupy approximately 1,800 square feet of the total Laboratory space available.

Equipment over $25,000: None.

Staff breakdown

Degree/Field	Scientific staff		Technical staff		Administrative staff		Staff total	
	Military	Civilian	Military	Civilian	Military	Civilian	Military	Civilian
Doctor of philosophy:								
Psychology		17						17
Educational psychology	1						1	
Masters: Psychology	4	10			1		5	10
Bachelor:								
Psychology	1	1					1	1
Electronics engineer				1				1
Library sciences						1		1
Math		1						1
Nondegree:								
Clerical						6		6
Supply					1		1	
Electronics technician				1				1
Totals	6	29		2	2	7	8	38

8. Arctic Aeromedical Laboratory, Ladd Air Force Base, Alaska

The Arctic Aeromedical Laboratory was organized in 1947 as the 1st Central Medical Establishment at the School of Aviation Medicine, USAF, Randolph AFB. It was almost immediately removed to Alaska where it has since then functioned at Ladd AFB, under the Alaskan Air Command.

The Laboratory's mission is defined in AFR 80–21, Aviation Medicine Research, and the 11th Air Division supplement to it. The AAL establishes technical requirements arising out of effects of the arctic environment on USAF personnel.

The research program is both basic and applied in nature. New techniques and procedures involving human performance are originated and placed in actual operation under laboratory auspices but capability of development of material and items is limited. The primary function of the Laboratory in this area is regarded as the delineation and tentative solution of developmental problems. Prototypes fabricated in accordance with these suggestions at other laboratories are then tested and evaluated under arctic conditions by this organization.

The Laboratory also provides support for other USAF aeromedical research facilities.

Current major programs

Human Acclimatization and Adaptation to Arctic Cold, Physiological and Psychological Problems of Survival in the Arctic, Aircrew Effectiveness under Arctic Conditions, Arctic Environmental Medicine, Arctic Personal Equipment and Clothing, Human Engineering and Psychophysiology in the Arctic, Defense Against Biological Warfare in the Arctic, Analysis of Human Factors Problems at Arctic Remote Sites.

Future anticipated major programs

It is anticipated that research on the major programs of current interest, as listed above, will be a continuing requirement. In addition, as missile operations are extended to the Arctic, research will be

conducted on the human factors problems involved. A start has already been made toward identifying those phases of temperate zone missile handling which are likely to require modification under arctic conditions.

Authority for present and anticipated future programs: AFR 80–20, Project Control Procedures, and 80–21, Aviation Medicine Research.

Suitability of present and planned facilities through fiscal year 1970

It is believed that present facilities and equipment, with the relatively minor additions and changes indicated below, will be entirely adequate for the foreseeable future for the performance of assigned missions. Important, nonmaterial assets of the Laboratory are its geographical location, within easy range of the full variety of arctic and subarctic habitats and its functional relationship with the Alaskan Air Command. As a consequence of its unique status as an integral part of a tactical command, its scientists are in firsthand contact with the problems which they are called upon to solve. Moreover, for scientific purposes, the entire command can be viewed as a practical extension of the Arctic Aeromedical Laboratory.

Role of the Laboratory in meeting life sciences research requirements for the armed services

The Arctic Aeromedical Laboratory is the only Human Factors Laboratory of the Department of Defense located in the Arctic and concerned exclusively with arctic problems. In any armed conflict in the foreseeable future, the Arctic, by virtue of its geographic location, is destined to be the scene of much human activity, both on the ground and within the lower atmosphere. It is believed that the Arctic Aeromedical Laboratory can serve a vital function for all of the armed services by continuing its efforts to solve the severe environmental problems of men working and living in the Arctic.

It should be realized that the thin protective shell of civilization, which insulates men from the rigors of the arctic climate and which makes northern Alaska as habitable as the District of Columbia, is exceedingly fragile and is totally dependent upon the continued functioning of such vulnerable facilities as centrally located heating plants. Thus, it is important that the Armed Forces retain their present capability of operating effectively under primitive conditions and that they not abandon their efforts to provide clothing, food, personal equipment, and emergency operating procedures adequate to cope with the austerity to be anticipated in time of war.

FISCAL DATA

Budget estimates for present and future programs

		Fiscal year 1960	Fiscal year 1961	Fiscal year 1962
P680	Contract funds	$435,000	$540,000	$500,000
P690	Laboratory operations funds	460,000	498,500	555,300
	Total	895,000	1,038,500	1,055,300

Costs of present and anticipated grants and contracts to nongovernment groups or educational institutions—by major category

	Program structure	
	Biologistics	Human performance
Fiscal year 1960	$360,000	$45,000
Fiscal year 1961	442,000	48,000
Fiscal year 1962	411,000	44,000

Capital investment in overall plant and equipment

	Plant	Equipment
Fiscal year 1960	$754,425	$356,438
Fiscal year 1961	849,425	424,148
Fiscal years 1962–63	1,039,425	533,438
Fiscal years 1964–70	(1)	(1)

[1] It is anticipated that during this period, plant and equipment will be adequate. Funds will be utilized for replacement only.

Description and costs of present and anticipated future services or project awards to other Government agencies for fiscal year 1961 and fiscal year 1962

Fiscal year 1960

A $30,000 cross-service agreement with the Arctic Health Research Center (a U.S. Public Health Service activity).

(1) Laboratory studies will be conducted to: (1) determine the effect of low pH (measure of acidity or alkalinity) environment in the aerobic recirculating waste treatment unit on the growth of nitrifying organisms (the absence of which causes a buildup of odor producing ammonia; (2) determine the effect of chemical and hydraulic parameters on the buildup of ammonia in the unit.

(2) Expand the surveillance of existing aerobic recirculating waste treatment units.

(3) Provide sanitary engineering competence in the person of a sanitary engineer stationed at the Laboratory to: (1) provide continuing survey of remote sites for delineation of problems; (2) perform and/or participate in research directed to solving these problems at AHRC and/or the Laboratory; (3) provide assistance to the Laboratory by participating in the review of other contractors for the Laboratory in the sanitation field.

Fiscal year 1961

A $10,000 cross-service agreement with naval hospital, Kodiak, Alaska. To develop and/or evaluate improved methods for treatment of local and general low temperature induced injury by chemical and physical methods.

A $10,000 cross-service agreement with Fort Detrick to evaluate problems and accomplish preliminary studies on the relationship of the arctic environment to biological warfare.

A $5,000 cross-service agreement with Army Chemical Center to evaluate problems and accomplish preliminary studies on the relationship of the arctic environment to chemical warfare.

A $25,000 cross-service agreement with Arctic Health Research Center to continue studies as outlined for fiscal year 1960.

Staff breakdown

	Scientific staff			Technical service staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of philosophy:							
Biology	1	1	2				2
Physiology		2	2				2
Biochemistry	[1] 1	2	2				2
Doctor of medicine:							
Flight surgeon	[2] 1		1				1
Pathologist	1		1				1
Other doctoral degrees:							
Doctor of veterinary medicine	2		2				2
Master's degrees:							
Bacteriology		2	2				2
Chemistry		2	2				2
Library science					1	1	1
Pharmacology				1		1	1
Physics		1	1				1
Physiology		1	1				1
Psychology	1		1				1
Bachelor's degree:							
Physiology	1		1				1
Business administration					1	1	1
Education (statistician)				1		1	1
Other personnel:							
Clerical				2	3	5	5
Custodial					1	1	1
Editing					1	1	1
Illustration					1	1	1
Shop				2	1	3	3
Supply				3	3	6	6
Animal caretaker					1	1	1
Research technicians	9	1	10				
Total	16	12	28	9	13	22	50

[1] Same individual possesses doctor of philosophy and doctor of medicine.
[2] Reflected as flight surgeon in totals.

One sanitary engineer is on loan from the U.S. Public Health Service. Incumbent is working on the development and evaluation of techniques for water treatment, waste disposal, food sanitation, and industrial hygiene in the USAF arctic environment. This loan was arranged after an intensive search, lasting over 2 years, failed to locate a qualified applicant for a permanent staff appointment.

Major physical resources

(*a*) Square feet of floor space: 27,184.
(*b*) Specialty laboratory facilities: None.
(*c*) Special items of research equipment ($25,000 or more per item): None.

9. Directorate of Air Force Bioastronautics, Military Space Systems, Air Force Ballistic Missile Division, Los Angeles, Calif.

The Directorate of Bioastronautics Projects, Air Force Ballistic Missile Division was established on April 23, 1958, by Headquarters, Air Research and Development Command. The mission established for the Directorate was, and remains, threefold: (1) To act as the office of technical management for all USAF biological space flight

programs; (2) to act as technical staff on bioastronautic matters to the Commander, Air Force Ballistic Missile Division, and to the Special Assistant for Bioastronautics at Headquarters, ARDC; (3) to act as liaison and coordination center on bioastronautic matters between civilian/military life science centers and contractors.

Current major programs

The Directorate of Bioastronautic Projects has five major program areas. The first is the technical management of current bioastronautic payload (Subsystem L Biomedical Recovery Capsule). The prime project in this area is the design, research, development, preflight test and flight test of biomedical recoverable capsule (Subsystem L) in the Discoverer series. The second major program area in the Directorate is the development of advanced biomedical recovery vehicles and life support subsystems (Advanced Biomedical Capsules. Current efforts include a study contract with Lockheed Missiles and Space Division which will culminate in a mockup of an advanced biomedical recovery capsule whose applied research objective is to exploit the present state of life support system technology to its practical limit. The third major program area in the Directorate involves research and development of prototype second generation life support system components (Advanced Component Development or ACD). Typical of these are contracts for development of miniaturized internally-implanted biotransensors and photosynthetic gas exchangers. The fourth major program area in the Directorate is the technical management of programs designed to return information concerning the bioastronautic space environment (Advanced Information Collection or AIC). Packages are being prepared for flight on Projects Discoverer, Piggyback and Spacer. Currently seven different packages are in preparation and range from prototype agravic photosynthetic gas exchangers, through tissue equivalent ionization detectors to agravic liquid gas interphase studies. The fifth main project area in the Directorate is bioastronautic analysis, prediction and programing. By mission definition, this Directorate has responsibility for bioastronautic Applied Research Objective preparation and documentation, Study Requirement Analysis, Planning Objective Generation, etc.

Future anticipated major programs through fiscal year 1970.

Headquarters, ARDC, has directed (see below) the AFBMD to prepare Planning Objectives for future bioastronautic efforts. When these planning objectives are approved by Headquarters, ARDC, this directorate anticipates being the office of bioastronautic technical management for seven major programs through 1970.

Authority for the present and anticipated future programs

Authority for present and future programs is contained in written directives from Headquarters, ARDC, based on approved USAF research and development requirements.

Suitability of present and planned facilities to the current and assumed future missions of your organization through fiscal year 1970

The present facilities of this Directorate are adequate for present missions. Present fiscal resources are adequate. Manpower resources

are inadequate. The adequacy of future facilities for assumed future missions will depend on moneys and personnel made available. If this Directorate gets the fiscal and manpower support it will require to prosecute planned programs, facilities will be adequate.

Other roles

Not applicable since this Directorate performs a direct, active role in astronautics.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–fiscal year 1962)

Total spendable dollars available to this Directorate in fiscal year 1960 are $308,000 (an additional $412,000 is frozen). In fiscal year 1961 the Directorate has 2.1 million available and fiscal year 1962 programs will require an expenditure of 2.4 million.

Costs of present and anticipated grants and contracts

The Directorate has made no grants or contracts to non-governmental groups or educational institutions and it is not anticipated that commitments in this regard will exceed 5 percent of available moneys. All moneys have thus far been let to other governmental groups for support of in-house effort (see below) or direct to large or small business contractors for research and development of hardware. In this later connection, expenditures have been made or are programed in the major research categories as follows.

Hardware R. & D. contracts

Category	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962
Biomedical Recovery Capsule	[1] 1.7 [2] 1.2	[1] [3] 5	[1] 0.5	
Advanced Biomedical Capsule		.080	1.10	1.80
Advanced Component Development		.064	.40	.50
Advanced Information Collection		.184	.60	.10
Subtotal (millions $)	[3] 1.2	[3] [5] .328	[3] 2.10	[3] 2.40
Total (millions $)	[4] 3.5	[4] [5] 3.828	[4] 2.60	2.40

[1] Dollars spent for biomedical recovery capsule by Discoverer Program Office.
[2] Dollars spent for biomedical recovery capsule by Directorate of Bioastronautics Projects.
[3] Dollars spent by Directorate in fiscal year.
[4] Dollars spent to support all Directorate activities in fiscal year.
[5] Dollars estimated in excess of dollars available (by .020 of one thousand.)

Capital investment in over-all plant and equipment, both present and anticipated, for future years through fiscal year 1970 (millions)

Category	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Plant	[1] 0.0091											
Personnel	[2] .017	0.014	0.021	0.028	0.035	0.042	0.053	0.053	0.053	0.053	0.053	0.053
GSE [6] Biomed	[3] .765			.5	1.0	.5	2.0					
GSE Non Bio-med	[4] .335			1.0	2.0	3.0	4.0					
Total	.1208	.014	.021	1.528	3.035	3.542	6.053	.053	.053	.053	.053	.053

[1] Based on building acquisition cost/net square footage × Directorate square footage or $696,160/45,453×594.
[2] Based on $297-man-month support costs, excluding salaries.
[3] Based on holding facilities, simulators, trainers, etc.
[4] Based on support hardware directly contributing to biomedical mission: special blockhouse instrumentation, special pad modifications, etc.
[6] Government supplied equipment.

Description and costs of present and anticipated future services or project awards to other governmental agencies for performance or performed at in-house facilities for other governmental agencies for fiscal year

(1) Fiscal year 1960: $38,000 to USAF School of Aviation Medicine for support of Project Piggyback experimental hardware.
(2) Fiscal year 1961: Unknown at this time.

Staff breakdown

	Scientific staff			Technical services		
	Military	Civilian	Total	Military	Civilian	Total
Ph.D.			0			
M.S.:						
Physiology	1		1			
Zoology	1		1			
Psychology	1		1			
B.S.:						
Chemistry	[1]1		1			
Aero. Eng.	[1]1					
Totals			4	0	0	0

[1] Same officer.

NOTE.—Other personnel:

Stenographer (GS-5)	1
Stenographer (GS-4)	1
Total	2

Numbers and types of personnel on loan

None.

Major physical resources

Square feet of floor space:
(1) Office—594 square feet
(2) Lab, shop, vans—2,060 square feet
(3) Total square feet—2,654 square feet

Special laboratory facilities:
(1) 2 medical vans
(2) 3 assembly and instrumental vans
(3) Auxilliary power unit vans
(4) Subsystem L checkout lab
(5) Blockhouse launch and readout station

Special items of research equipment

None.

10. HUMAN ENGINEERING LABORATORY, ROME AIR DEVELOPMENT CENTER, GRIFFISS AIR FORCE BASE, N.Y.

The Human Engineering Laboratory, Rome Air Development Center, in compliance with a letter from Headquarters, ARDC, was originally organized in June 1951, as the Human Factors Office to provide direct assistance to design and development engineering on problems caused by and/or related to the utilization of the human being in the operation of ground electronic equipment and systems.

The current mission of the Laboratory is to perform human engineering analysis, evaluation, research, and application to design and development problems involving equipment and systems developed by the Rome Air Development Center. The scope of its mission at present and in the future is determined by the scope of the RADC mission. The Laboratory now supports engineering research and development activities in such areas as control and guidance, communications, and intelligence and electronic warfare, and biological effects of microwave radiation. This support takes such forms as (*a*) consultation, (*b*) participation in equipment and systems design, development, and test, (*c*) monitoring of contracts, and (*d*) mission-oriented applied and basic research.

Current major programs

1. Image quality factors in reconnaissance interpretation.
2. Recognition of visual targets in complex fields.
3. Development of formats and symbologies for displays to aid intelligence data processing.
4. Masking of speech with bands of noise.
5. Information processing as a function of sense modality.
6. Data presentation techniques for control of forces.
7. Biological effects of microwave radiating equipments.

Future anticipated major programs

1. Data presentation techniques for control of strategic and tactical missiles.
2. Influence of display variables on command and control decisions.
3. Human capacity to discriminate nose cones in ballistic trajectories.
4. Binaural localization.
5. Development of intelligibility tests and testing techniques.
6. Discrimination of pitch, with adaptation as a primary variable.
7. Time and bandwidth conservation.
8. Research on the reconnaissance interpretation and reconnaissance charting functions.
9. Research on the intelligence analyst function.
10. Biological effects of microwave as it pertains to future radiation weapons programs.

Program authority

Authority for the program is contained in ARDC directives which are based on approved USAF requirements.

Suitability of present and planned facilities

The present and anticipated facilities of the installation are considered suitable for current and assumed future missions of the Human Engineering Laboratory.

Roles in support of life sciences research requirements other than astronautics

The Human Engineering Laboratory is capable of and does perform a wide range of basic and applied research tasks on psychological and human engineering problems involved in the development of Command and Control, and Intelligence systems.

FISCAL DATA

Budget estimates for present and future programs

Fiscal year 1960	$478,000
Fiscal year 1961	560,000
Fiscal year 1962	815,000

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories of research

Studies on the recognizability of visual targets in complex fields:

Fiscal year 1960	$60,000
Fiscal year 1961	30,000
Fiscal year 1962	30,000
Fiscal year 1963	30,000

	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962	Fiscal year 1963
Studies of basic variables influencing human ability to estimate absolute and relative position, velocity and acceleration of targets moving in two and three dimensions		$30,000	$35,000	$35,000
Studies on the binaural localization of speech sounds			50,000	30,000
Study of the psychological variables affecting command control decision and development of the most effective techniques for efficient, economical presentation of information appropriate to specific decision situations	$118,000	300,000	500,000	
Studies to determine biological changes and their mechanisms in animals exposed to microwave radiation. Also to correlate such data to man	300,000	200,000	200,000	200,000
Total	418,000	530,000	785,000	265,000

Capital investment in overall plant and equipment

The present investment is about $270,000. No major change in the size of this investment is anticipated through fiscal year 1970.

Description and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies for fiscal year 1960 and fiscal year 1961

At present there exist no such awards, and no services are currently performed or planned at in-house facilities for other Government agencies.

Staff breakdown

	Scientific staff			Technical Service			Staff total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of philosophy: Psychology	2	4	6				6
Master of arts:							
Psychology	4	9	13				13
Biology		1	1				1
Bachelor of arts:							
Psychology		1	1				1
Electronic engineer		1	1				1
Supporting personnel:							
Bachelor of arts:							
Physics		[1] 1					1
No degree: Electrical engineer	[1] 1						1
Total							23

[1] Technician lab. facilities.

No personnel are on loan to or from other governmental agencies.

Major physical resources

The Human Engineering Laboratory occupies 3,200 square feet of floor space. An additional 1,900 square feet is utilized at an off-base site.

There is a research facility which includes equipment for research on visual, auditory and tactile functions, recording of physiological responses (e.g., electrocardiogram, blood pressure, respiration rate), cathode ray tube detection studies, etc. The facility includes both darkrooms and a sound chamber. A radiofrequency anechoic chamber for whole body microwave exposures of animals along with necessary radiofrequency generating equipment.

Special items of research equipment ($25,000 or more)

None.

11. Human Factors Branch, Directorate of Flight Test, Air Force Flight Test Center, Edwards Air Force Base, Calif.

The Human Factors Branch is assigned to the Flight Test Engineering Division, Directorate of Flight Test of the Air Force Flight Test Center, Edwards AFB, Calif. The mission of the Human Factors Branch is to evaluate the human factors design and functional characteristics of Air Force weapons systems, manned spacecraft, and personal equipment under flight test and other special test conditions. The branch also conducts projects in the human factors field as requested by other inservice research and development agencies.

Current major programs

Programs presently active within the Human Factors Branch are those normally connected with weapons systems evaluation; e.g., B–52, heavy bomber, C–133, cargo aircraft, H–43, helicopter. Also active are:

(1) X–15, experimental rocket airplane, physiological telemetered data console development.

(2) X–15 physiological data package development.
(3) X–15 oxygen consumption study in TF–102, trainer version of F–102 interceptor, and low pressure chamber.
(4) X–15 pressure suit maintenance and test program in TF–102 and low pressure chamber.
(5) Zero–gravity flight test support program, including facilities, instrumentation, and chase aircraft.
(6) Night lighting evaluation, portable tool development.
(7) Dyna-Soar, (advanced design experimental manned boost-glide aircraft), medical evaluation and pilot selection procedures.

Future anticipated major programs through fiscal year 1970

The proposed programs to be initiated at this center through fiscal year 1970 in which the Human Factors Branch will participate are:

(1) Dynamic simulation of flight profiles of aerospace vehicles using a gondola capable of 6 degrees of freedom with an analogue computer tie-in for closed loop simulation in the selection and training of astronauts.

(2) An environmental evaluation using the dynamic simulator and other equipment will include the following parameters; atmosphere, temperature, acceleration, and cabin habitability. This will allow evaluation of the reliability and suitability of components to be used, and the training of aerospace personnel under realistic conditions.

(3) Expansion of the present capability for evaluation of personal equipment. This expansion will include, but not be limited to:

(*a*) An increase in floor space.

(*b*) The purchase of an improved mobile van in support of the full pressure-suit.

(*c*) The obtaining of a two-place, high-performance, variable-stability test bed aircraft.

The additional floor space is badly needed. The new van will rectify certain shortcomings in the present system, and the aircraft will permit simultaneous investigation of personal equipment, environmental systems, and pilot energy management.

(4) Advanced aeromedical airborne instrumentation and telemetry. The objective of this program is to obtain a micro-miniaturized system that will monitor both environmental and physiological parameters, and which will telemeter this information without burdening the pilot with an electrical umbilicus.

(5) An astronaut selection and training program will be maintained on a continuing basis. The basic tools for the selection of candidates have been developed. The medical and psychophysical selection tools can be economically implemented at Edwards, the site of the largest pool of test pilot experience in the country. Training can be continued from the day of selection to the day of the mission.

(6) Escape systems will be demonstrated and their reliability established. The high speed track facility offers excellent opportunity to subject escape systems to the necessary high Q (ram pressure) and low altitude regime. The local bombing ranges offer recovery areas for free fall, sub and supersonic demonstration. The users could then be aware of escape systems capabilities and shortcomings without extensive travel to gain this knowledge.

Authority for present and planned facilities

The authority for the present programs is contained in the following USAF approved projects and tasks:

(1) X–15 Physiological console.
(2) X–15 Physiological package.
(3) X–15 Oxygen consumption data.
(4) X–15 Pressure suit maintenance and test.
(5) Zero G flight test support program.
(6) Night lighting evaluation.
(7) Dyna-Soar selection.

Suitability of present and planned facilities through fiscal year 1970

Present facilities are satisfactory for current programs with the exception of the low pressure chamber building which needs an immediate expansion of 3,350 square feet. Proposed future programs will require the development of a new mobile van in support of the full pressure suit, a physiological data readout console, and a dynamic simulator.

Other roles in meeting life sciences research requirements

If a mission in support of astronautics is not assigned, weapon system and personal equipment evaluations would continue as in the past.

FISCAL DATA

Budget estimates for present and future programs

	Fiscal year 1960	Fiscal year 1961	Fiscal year 1962
(1) Programs in being:			
(a) X-15 pressure suit maintenance and test	$80,000	$100,000	$100,000
(b) Flight research and physiological data console	195,000	15,000	25,000
(c) In-house instrumentation development	15,000		
(d) Physiological data package	35,000	100,000	30,000
(e) Dyna-Soar selection	7,800	30,000	12,000
(2) Programs proposed:			
(a) Dynamic simulator, training		200,000	1,000,000
(b) Other instrumentation development	55,000	105,000	185,000
Total	387,800	550,000	1,352,000

Cost of present and anticipated grants and contracts

No grants or contracts to nongovernmental groups or educational institutions are anticipated.

Total capital investment

The present capital investment is $2,124,666. The future investment for planned programs will be approximately $5 million.

Description and costs of present and anticipated future services

In-house effort during fiscal year 1961 and fiscal year 1962 for the School of Aviation Medicine will total $155,000.

Staff breakdown

	Scientific staff			Administrative and technical support staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of medicine:							
Flight surgeon	1		1				1
Master's degree:							
Psychology	3		3				3
Optometry	1		1				1
Education	1		1				1
Bachelor's degree:							
Physiology	1		1				1
Administrative					1	1	1
Technical support				1		1	1
Totals	7		7	1	1	2	9

Number and types of personnel on loan to other Government agencies or on loan from other Government agencies

There are no personnel on loan to other agencies.

Major physical resources

Square feet of floor space.—Office space occupied by the Human Factors Branch is 906 square feet. The low-pressure chamber encompasses 6,000 square feet. Some additional floor space is utilized by instrumentation personnel and equipment; however, the amount varies and is not permanently assigned to human factors activities.

Special laboratory facilities.—The TF–102 aircraft, low-pressure chamber and physiological instrumentation are the only special laboratory facilities used by this branch.

Special items of research equipment.—Special items of equipment worth $25,000 or more:

(1) Modified TF–102 aircraft.
(2) Low-pressure chamber.

12. Missile Test and Range Support Division, Office of the Staff Surgeon, Air Force Missile Test Center, Patrick Air Force Base, Fla.

The Office of the Staff Surgeon, AFMTC, has several separate and distinct but interrelated missions. The primary mission is to supervise all center medical resources. This includes representing the Commander, AFMTC, in medical matters affecting agreements with the Range Contractor and developing the medical portion of center plans and programs. This staff agency is included in this study because, although it conducts no actual research and development projects, its support services for Project Mercury and for the Nation's missile test programs are closely related to some of the life science research programs included in the study.

The Occupational Health Research Laboratory has been renamed the Missile Test and Range Support Division. The functional area of concern to this staff section involves all phases of missile operations occurring at the Atlantic missile range which is the free world's largest and longest outdoor laboratory. It is the place where all branches of the U.S. Military flight-test their major missile systems.

It is where present and future unmanned and manned space projects are scheduled for testing and launch. The Atlantic missile range is part of AFMTC. This includes headquarters at Patrick Air Force Base, a 5,000-mile range (down the Atlantic from Cape Canaveral to Ascension Island), 12 island-based tracking stations, 11 airfields, more than 40 aircraft and 11 picket ships equipped to track missiles.

Mission

The mission of the Missile Test and Range Support Division is to develop plans and programs for medical support of missile tests and missile range facilities. This requires identifying and investigating occupational health hazards associated with missile prelaunch and launch activities. Preventive medical information is thereby obtained for use by missile test personnel, as well as those personnel in operational missile units. To accomplish this, industrial hygiene studies are periodically performed along with laboratory analyses, medical examinations, and surveys on the physical aspects of missile operations, such as noise and blast. These studies and surveys aid in the establishment of requirements and standards for protective clothing and equipment, thereby helping to safeguard personnel during missile tests. Essentially, personnel in this division formulate tasks and monitor their implementation by personnel of the Pan American Airways Medical Department (contract operator, Atlantic Missile Range). In addition, the human factors of missile operations are covered by devising selection criteria and training programs for missile units by human engineering of the complete missile weapon system, and by investigating the nature and characteristics of human errors and accidents in all facets of missile activities.

The Staff Surgeon is also charged with formulating and conducting a course of instruction entitled "Medical Aspects of Missile and Space Operations." The objective of the week-long course, conducted once each month during 9 months of the year, is to indoctrinate senior medical officers of the Army, Navy, and Air Force in the medical and occupational health problems incident to missile operations.

The advent of manned and unmanned space project activities at AFMTC has been primarily responsible for the creation of an additional major mission element within the Office of the Staff Surgeon, the Bioastronautics Support Division, and has necessitated a change in emphasis. The division is responsible for bioastronautics activities assigned to the Staff Surgeon in support of space programs conducted at AFMTC. In turn, the Surgeons General of each of the three military medical departments have designated a representative to speak for their respective medical service in the negotiations leading to the provision of such medical support as may be required for Project Mercury flight operations.

The bioastronautic support of Project Mercury may be divided into three broad categories: (*a*) The medical care of the astronauts; (*b*) the aeromedical monitoring at global range stations; and (*c*) the medical support of postflight operations. With respect to (*a*), this agency has been requested to assume responsibility for the feeding of the astronauts for a period immediately prior to launch. To help accomplish point (*b*), the three services have made available approximately 30 medical officers to the National Aeronautics and Space Ad-

ministration Space Task Group. These officers will serve as aeromedical monitors at various locations on the global range. In addition, a 1-week basic orientation course will be presented to these medical monitors at the AFMTC. This course will precede the training program to be conducted by the National Aeronautics and Space Administration. The U.S. Navy has been assigned the responsibility for developing an overal plan for medical support of postflight operations.

Future anticipated major programs through fiscal year 1970

The mission of supervising all center medical resources will continue essentially as currently programed. This means future programs will continue to emphasize staff monitoring of Range Contractor medical functions, facilities, and plans. Current efforts will continue to strive for a coordinated, integrated medical program.

The Missile and Range Support Division will continue to disseminate to operational and missile test units the findings resulting from its surveys and studies. An increase in activities will occur now that full manning has been achieved and essential testing equipment has been received. Future program objectives for the division will be defined as new missile and space systems are introduced to the Atlantic missile range.

The "Medical Aspects of Missile and Space Operations" course of instruction has, as stated earlier, already undergone a relatively major shift in emphasis as a result of the space project activities occurring at the Atlantic missile range.

It is anticipated that future program objectives will be realized through continued and perhaps increased emphasis on the medical aspects of space operations. However, this does not necessarily mean that the medical aspects of missile operations will decrease in importance. Missile weapon systems are barely coming of age and it should be stressed that medical problems will be constantly recurring and very important. In addition, missile systems and not space systems will constitute the huge majority of activity. The variety and sheer numbers of missile weapon systems make it mandatory that medical personnel be trained in the essential medical problems.

The solution to continued emphasis on both kinds of medical problems is to increase the length of the course. Plans have been made to increase the course duration from 1 to 2 full weeks.

It is anticipated that the mission of the Bioastronautic Division will increase in scope and intensity as projected manned space flight activities are programed and tasks are received. As mentioned earlier, the staff surgeon has been given the responsibility for providing a period of concentrated training for the selected Project Mercury medical monitors. The training course has been officially approved as an integral phase of the monitoring training program.

This essential step should be followed by courses specially flight designed to provide the Department of Defense with trained space surgeons both as potential replacements for the Mercury medical monitors and for use in follow-on manned space projects.

Future programs should include emphasis in the area of medical support of recovery operations in manned space projects.

It is anticipated that a holding facility will be required to help train and condition astronauts for future space flights. Such a facility

would allow for the simulation of the more important parameters of man in space to be tested and checked out as an integral part of the hardware components.

Authority for present and anticipated future programs

Pertinent directives from Headquarters, U.S. Air Force and Air Research and Development Command.

Suitability of your present and planned facilities to the current and assumed future missions of your organization through fiscal year 1970

A program directed at the creation of a holding facility for the training and conditioning of astronauts is needed to achieve the future objectives.

FISCAL DATA

Not applicable since this staff agency conducts no research and development program.

Staff breakdown

	Scientific staff			Technical service			Staff total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of philosophy: Psychology	1	0	1	0	0	0	1
Doctor of medicine:							
Flight surgeon	1	0	1	0	0	0	1
Industrial physician	1	0	1	0	0	0	1
Doctor of dental surgery	1	0	1	0	0	0	1
Masters degree: Psychology	1	0	1	0	0	0	1
Bachelor degrees:							
B.C.E., civil engineering	1	0	1	0	0	0	1
Chemical engineering	1	0	1	0	0	0	1
Engineering physics	1	0	1	0	0	0	1
Total							8

NOTE.—Other personnel:

Administrative officer	1
Civilian secretary	1
Civilian clerk-typist	2
Civilian illustrator	1
Total	5

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies

None.

Major physical resources

Square feet of floor space: 9,060.

Special laboratory facilities:

(1) 300 square feet of existing Chemical Laboratory.

(2) About 500 square feet programed in the Medical Science Laboratory at Cape Canaveral.

Special items of research equipment: None.

13. HUMAN FACTORS OFFICE, AIR PROVING GROUND CENTER, EGLIN AIR FORCE BASE, FLA.

The APGC's Human Factors Office was established in March 1958 to fulfill a vital part of the Air Force's weapon system testing program.

The inclusion of this office in the Air Proving Ground Center provides for more comprehensive and valid system evaluation by accounting for human variables and determining their impact on the weapon system. The capability of the operator, maintenance, and support personnel for increasing or decreasing the successful accomplishment of a mission is a primary factor in the total system effectiveness. The human component must be considered as a part of the total sytem.

The mission of this Office is to conduct studies and tests of the man-machine-environmental relationships that influence a weapon system's effectiveness.

Those areas which are included in APGC's general human factors evaluations cover a wide range of considerations as to the performance of the personnel, their environment, and general well-being. As an example of these considerations, the following list is presented:

(1) Operational and maintenance concepts.
(2) Selection of personnel, including manning requirements.
(3) Human engineering.
(4) Training.
(5) Proficiency assessment.
(6) Morale, motivation and retention.
(7) Environmental protection, including air and ground safety.
(8) Handbook, manuals and job aids evaluation.

Current major programs

No basic research or technical development programs are being conducted by this Office. Fourteen project officers are responsible for 16 active test projects. Five of the tests are being conducted off base. See current test projects below in table titled "Current APGC Human Factors Office Projects."

Future anticipated major programs through fiscal year 1970

The program contained in attachment 2 will carry into fiscal year 1963. Because of the uncertainty of the exact nature of this Center's role in support of the Development Division, it is not possible to plan realistically beyond this program.

Authority for present and anticipated future programs at the installations involved

The authority is contained in directives from the Weapon System Project Offices, Headquarters Air Research and Development Command, Headquarters USAF, and in directives to support APGC in its developments, studies, and tests by applying: (a) biomedical, (b) personnel, (c) training, and (d) human engineering testing experience to Air Force weapon systems.

Suitability of your present and planned facilities to the current and assumed future missions of your organization through fiscal year 1970

No increase in facilities is planned and present support is adequate.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–fiscal year 1962

(1) Fiscal year 1960	$235,080
(2) Fiscal year 1961	203,652
(3) Fiscal year 1962	240,000

Cost of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories of research

None.

Capital investment in overall plant and equipment, both at present and anticipated for future years through fiscal year 1970

Equipment consists only of normal supply items such as typewriters, desk calculators, dictaphones, safes, and tape recorders. Capital investment is approximately $10,000 and should remain at this figure unless our mission changes.

Description and costs of present and anticipated future services or project awards to other Government agencies for performance or performed at inhouse facilities for other Government agencies for fiscal year 1960 and fiscal year 1961

None.

Staff breakdown

(1) Scientific staff:

Military	7
Civilian	9
Total	16

(2) Technical service:

Military	1
Civilian	3
Total	4

(3) (*a*) Degrees:

Doctors of philosophy:	
Physiology	1
Education	2
Masters of arts:	
Psychology	7
Education and mathematics	1
Bachelors of science:	
Biology	1
Civil engineer (industrial hygiene engineer)	1
Psychology	2

Totals: 3 doctors of philosophy, 8 master of arts, and 4 bachelor of science.

(*b*) Supporting personnel other than above, military and civilian by function: None.

Number and types of personnel on loan to other Government agencies or on loan from other Government agencies

None.

Major physical resources

Square feet of floor space: 2,200 square feet of office space.
Special laboratory facilities (see below under "Facilities").
Special items of research equipment ($25,000 or more): None.

Current APGC human factors office projects, Apr. 1, 1960

Short title	Project status	APGC priority	Termination date
1. IM99 SAGE–Bomarc A	Testing	5	Classified (suspended).
2. IM99 Bomarc B	do	5	Do.
3. QB–47 Drone	do	5	July 1960.
4. T–29 Aircraft	do	5	Do.
5. B–52G ECM [1]	Report writing	8	June 1960.
6. GAM–77 (Hound Dog)	Testing	9	Classified (canceled).
7. GAM–72 (Quail)	do	14	Do.
8. FD [2] Radar-Eufaula, Ala.; Houma, La., Grove Hill, Ala.; Crystal Springs, Miss.; Dauphin Island, Ala.	do	15	Classified (suspended).
9. B–58 (Fort Worth)	Testing; report writing, planning.	17	Do.
10. AWCS [3] (Shaw Field, S.C.; Myrtle Beach, S.C.), etc	Monitoring human factors activities.	19	Unknown.
11. B–58 (Fort Worth) Mk 28/Warhead	Planning	17	July 1960.
12. F–105B Aircraft	Testing	26	Classified.
13. F–105D Aircraft	do	26	Classified (suspended).
14. GAM 83A	do	26	Do.
15. GAM 87	Planning	10	Do.
16. B–52H	do	8	Unknown.

[1] ECM: electronic countermeasures.
[2] FD: frequency diversity radar.
[3] AWCS: Air Weapons Control System.

Eglin Range—B–70: This is a future project. The extent of active participation has not yet been determined.

Other roles the human factors office of APGC could perform in meeting life sciences research requirements of the armed services

The Human Factors Office of APGC will continue to maintain a capability to conduct human factors systems testing and evaluation. This capability is utilized to provide APGC/ARDC with a human factors testing and evaluation capability for weapon systems and supporting systems. In addition, AFR 80–14 states that ARDC will provide technical assistance during category III testing as required by responsible test organization. Since the APGC Human Factors Office represents a large portion of ARDC's human factors system test capability, it is anticipated that there will be an increasing requirement for participation in such testing. Category III test partcipation in tests presently assigned to APGC, will require approximately 10 percent of the available resources during fiscal year 1960, approximately 20 percent during fiscal year 61, and 35 percent during fiscal year 1962. Presently, the support required in categories I and II testing activities does not appear to be diminishing. (See categories below).

If personnel were available, two additional areas in which effort could be expended are: (1) in the evaluation of the utility and suitability of personnel equipment and (2) in determining aspects of the environmental conditions which should be optimized in order to obtain and maintain maximum performance of advanced aircraft and space crews.

Equipment utilization section

Testing Category I: subsystems development, test and evaluation.
Testing Category II: system development, test and evaluation.
Testing Category III: system operational test and evaluation.

Parameters:

1. Equipment analysis:
   - Reliability.
   - Availability.
   - Compatibility with weapon system.
   - Maintenance, inspection, calibration, checkout.
2. Personnel acceptance:
   - Safety.
   - Comfort.
   - Convenience.
   - Confidence.
   - Skill requirements.
   - Information requirements.
   - Standard operating procedures.
   - Anthropological compatibility.
   - Mission relationships.

Professional cognizance:

- Human engineering.
- Personnel and measurements.
- Training.
- Physiology.
- Statistics.
- Personnel equipment characteristics.
- System operations.
- Accident analysis.

Facilities

The following special research and test facilities are available at this center:

Climatic laboratory:

(1) Desert room (12'x12') temperature range from 60° F. to 120° F. with humidity control.

(2) Hot test room (12'x12') temperature range from 70° F. to 120° F. with humidity control.

(3) Cool test room (10' x 12') temperature range from 95° F. to −70° F.

(4) Physiological stratochamber (9½' x 12') altitude from ground level to 80,000'. Temperature from 70° F. to −70° F.

Altitude chambers:

(1) Twenty-man chamber—E modification for 16 men (20' x 9').

(2) Group chamber, "Parasite"—indoctrination of partial pressure suit (15' x 6'') rapid decompression to 75,000'. Profile runs lasting from 1 to 6 hours supervised by qualified personnel are possible. A minimum amount of equipment for instrumentation purposes is required.

Data reduction laboratory:

(1) Five computers.

(*a*) IBM 704 data processing machine.
(*b*) 1103 Univac Scientific.
(*c*) IBM 650 magnetic drum computer.
(*d*) 203 Dataron.
(*e*) Analogue—Readix.

(2) Associated machines for card handling, tabulation, sorting, etc.

Psychiatric facilities: (1) A neuropsychiatric department in the base hospital consisting of eight psychiatrists and two psychologists are available for consultation.

Subjects: (1) Approximately 50 test pilots with combined experience in all latest model aircraft are assigned to this Center.

14. Training Equipment Branch, Simulator Research Section, Aeronautical Accessories Laboratory, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio

In 1957 it became apparent that the problem of training operator and maintenance personnel was rapidly outstripping the available technology. Several outstanding engineers and scientists were selected from the various groups involved in the production of training equipment and organized into the Simulator Research Section. The purpose of this section is to develop new and improved engineering techniques for the design, development, and evaluation of simulation equipment for the training of human components of advanced weapon systems.

Programs

The effort of the Simulator Research Section is presently broken down into six areas. These are listed below:

(1) Mathematical studies.
(2) Computer components.
(3) System synthesis.
(4) Display synthesis.
(5) Environmental simulation.
(6) Monitoring and scoring.

The major goal of the effort in these six areas is to produce flexible electronic simulation equipment capable of supporting training and human factor research from the outset of a weapon system development. A recent breakthrough in digital simulation development jointly with the Navy, a Universal Digital Operational Flight Trainer, is typical of the desired capability. Present plans are to use UDOFT for training and design studies on Dyna-Soar.

In the future, the major areas of effort will remain the same; however, the emphasis will shift from simulation equipment to monitoring, scoring, and synthetic simulation of environment. The new scientific discipline of bionics is expected to contribute heavily in the future.

The authority for present and anticipated programs is the Air Research and Development Command Applied Research Objective: "Training Equipment, Simulators and Techniques for Air Force Systems."

Facilities

Present facilities consist of approximately 1,300 square feet of floor space, a small analog computer, and miscellaneous recording and measuring equipment. The floor space is presently inadequate—at least 1,000 additional square feet of space are needed. The analog computer

is obsolete and should be replaced as quickly as possible. There is a need for a small digital computing facility.

The present program is oriented to astronautics; however, the techniques and equipment developed are equally pertinent to airborne weapon systems. In the event that the organization were not assigned a role in astronautics, it could with only minor reorientation, produce valuable results in the field of airborne weapon systems. It is further possible to provide techniques and equipment of value to military ground forces.

FISCAL DATA

Budget estimates for the present and near future are as follows

(1) Fiscal year 1960; $822,000.
(2) Fiscal year 1961; $922,000.
(3) Fiscal year 1962; $1,072,000.

Costs of present contractual commitments to non-Government groups are as follows

(1) Mathematical studies: Studies to produce mathematical models or descriptions of vehicles, vehicle systems, etc., so that the vehicle and systems can be simulated; $75,000.

(2) Computer components: Development of computer components such as function generators, multipliers, etc.; $35,000.

(3) System synthesis: Develop flexible simulation techniques for simulating systems, i.e., hydraulic, electrical; $100,000.

(4) Display synthesis: Develop simulation techniques for visual landing, et cetera; $190,000.

(5) Environmental synthesis: Develop techniques for simulating aerospace environment synthetically; $140,000.

(6) Monitoring and scoring: Develop techniques and hardware to monitor and score the performance personnel being trained; $210,000.

Costs of future contractual efforts will be similar in distribution. There will be a requirement for approximately 25 percent to 50 percent additional funding.

Present capital investment is estimated at $200,000. It is estimated that this will increase to $500,000 when obsolete equipment is replaced and facilities are expanded where required.

There are no plans at present to obtain services or award projects to other Government services. Assistance has been given informally in the past to such groups as NASA and the Federal Aviation Agency. No formal programs with other organizations are anticipated for the immediate future.

Staff breakdown

	Military	Civilian	Total
Scientific staff:			
Master of science, electrical engineering	1	2	3
Bachelor of science, electrical engineering		1	1
Bachelor of science, mathematics		1	1
Bachelor of science, mechanical engineering		2	2
Support staff:			
Administrative		1	1
Technical		1	1

DEPARTMENT OF THE NAVY

A. Department of the Navy Fiscal Summary for Aerospace Related Life Science Programs

Installations	Research budget [3] [1]		Present value of installations
	Fiscal year 1960	Fiscal year 1961	
U.S. Naval Medical Research Institute	[2] 3,815,000	[2] 4,250,000	$4,922,000
U.S. Naval Medical Research Laboratory			498,546
U.S. Naval School of Aviation Medicine			5,408,000
Aviation Medical Acceleration Laboratory			11,491,000
Air Crew Equipment Laboratory			5,616,000
U.S. Naval Missile Center [3]			1,458,000
Biological and Psychological Sciences Division, Office of Naval Research	1,430,000	1,435,000	
U.S. Naval Research Laboratory	564,000	626,000	500,000
U.S. Naval Training Device Center	146,000	165,000	125,000
Total	5,955,000	6,476,000	30,018,546

[1] Combined fiscal data for 6 of the above activities and the Navy bureaus. The combined intramural research budgets for the following U.S. Naval activities are indicated below: Air Crew Equipment Laboratory, Aviation Medical Acceleration Laboratory, Naval Missile Center, School of Aviation Medicine, Naval Medical Research Institute (Bethesda), and the Naval Medical Research Laboratory (New London, Conn.):

Fiscal year 1960	$2,251,000
Fiscal year 1961	2,047,000

Contracts and grants to nongovernmental groups

	Fiscal year 1960	Fiscal year 1961
Escape, survival, recovery, and rescue	$907,000	$1,218,000
Physiological protective systems and personal equipment	657,000	985,000

For the U.S. Naval agencies listed in this paragraph, it is anticipated that any project awards to other Government agencies or in-house research to be performed for other Government agencies will be limited to certain support tasks for NASA's Project Mercury. No estimate of funding is available at this time.

[2] Includes contract funds for Navy bureaus aerospace life sciences contracts.

[3] Not a life sciences laboratory; however various items of its equipment are being used for life sciences research and test.

B. Department of the Navy Staffing Summary for Aerospace Related Life Science Programs

Installations	Doctors [1]		Masters		Bachelors		Supporting Staff [2]		Total
	Military	Civilian	Military	Civilian	Military	Civilian	Military	Civilian	
U.S. Naval Medical Research Institute	28	21	4	9	9	10	102	103	286
U.S. Naval Medical Research Laboratory	9	12	-------	4	2	9	35	23	94
U.S. Naval School of Aviation Medicine	21	10	4	4	4	8	-------	-------	51
Aviation Medical Acceleration Laboratory	6	10	2	8	2	8	-------	-------	36
Air Crew Equipment Laboratory	4	3	1	3	1	27	19	61	119
U.S. Naval Missile Center	5	3	1	1	2	1	5	1	19
Biological and Psychological Sciences Division, Office of Naval Research	1	11	-------	4	-------	4	-------	13	33
U.S. Naval Research Laboratory	-------	14	-------	22	-------	21	-------	-------	57
U.S. Naval Training Device Center	-------	3	-------	3	-------	2	-------	4	12
Total	74	87	12	58	20	90	161	205	707

[1] Includes M.D.'s, Ph.D.'s, dentists, veterinarians.
[2] Includes technicians, stenographers, and other support personnel.

C. Life Science Programs

1. U.S. Naval Missile Center, Point Mugu, Calif.
2. Biological and Psychological Sciences Divisions, Office of the Assistant Chief for Research, Office of Naval Research.
3. U.S. Naval Research Laboratory, Office of Naval Research, Washington, D.C.
4. U.S. Naval Training Device Center, Office of Naval Research.
5. U.S. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md.
6. U.S. Naval Medical Research Laboratory, Submarine Base, New London, Conn.
7. U.S. Naval School of Aviation Medicine, U.S. Naval Aviation Medical Center, Pensacola, Fla.
8. Aviation Medical Acceleration Laboratory, U.S. Naval Air Development Center, Johnsville, Pa.
9. Air Crew Equipment Laboratory, U.S. Naval Air Material Center, Philadelphia, Pa.

1. U.S. Naval Missile Center, Point Mugu, Calif.

The Bioscience Office of the Pacific Missile Range was established on March 2, 1959, to be responsible to the Deputy Commander, PMR, for analyzing and coordinating ground support requirements for range users for bioscience and medical facilities in missile and space vehicles programs, including: planning for such medical facilities, procedures and/or personnel protective equipment to support range operational requirements; the planning for providing biological facilities on the range complex to support national bioastronautics programs; the initiating of programs or projects to correct existing or

anticipated medical and bioastronautics range deficiencies and facilities, personnel equipment and/or procedures; effecting liaison and coordination of PMR activities with industry, universities, and nonprofit organizations and other Government agencies interested in or concerned with bioscience; and the planning of long-range bioscience programs.

The Life Sciences Department was established on October 20, 1959 in full agreement with the policy of the Chief of Naval Operations to be responsible to the Director, Missile and Astronautics, for the direction, planning, coordination, and administration of basic and applied research in aerospace medicine in support of naval, or other national requirements as assigned, and, as programed by the Bioscience Office to support range operation requirements, including; behavioral science, environmental survival and safety, personnel selection, and training methods and devices; the prosecution of programs which may in turn be delegated as tasks or subtasks to other departments; the maintenance of a continuing program of inquiry into present and future needs within the areas of assigned responsibilities; the coordination with laboratory and other organizational elements for the development of facilities to supplement the national capabilities in the field of life sciences; the maintenance of liaison and coordination with cognizant governmental, universities, and industrial officials in other agencies concerned in the related functions or theories; the presentation and justification of long-range programs to the Director or higher authority, and the dissemination of information to interested and cognizant military and scientific groups, as directed.

Current major programs

Biological

AERO	SPACE
1. Laboratory and operational investigation of high altitude environments. (*a*) Human exposure to 34,000; 100% O_2. (*b*) Acclimatized human exposure to 40,000; 100% O_2 for 1 day. (*c*) Long-term exposure of animals to 34,000; 100% O_2. 2. Studies of toxicity, noise and heat hazards of guided missile systems.	1. Provide laboratory, basic support and project liaison with range for biopack operations pending development of in-house capability.

Psychological

1. Effects of vibration on performance:
   (*a*) On helicopter pilot proficiency.
   (*b*) Effects of preconditioning.

Medical

1. Real time monitoring and recording of physiological data (electrocardiogram, electroencephalogram) from air crews during high performance missile system flight tests.
2. Operational evaluation of Mark IV Full Pressure Suit.

AERO

1. Monitor consoles for display of physiological data during guided missile operations.
2. Recording of physiological data for postflight analysis.
3. Prepost flight examination of pilots.
4. Development and evaluation of operational bioinstrumentation.

SPACE

1. Monitor consoles for display of physiological data during orbital and probe operations.
2. Recording of physiological data for postflight analysis.
3. Prepost flight examination of astronauts.
4. Development and evalution of operational bioinstrumentation.

Future major programs

Biological

AERO

1. Maintenance and training for new air crew personal equipment.
2. Effects of vibration on altitude tolerance.
3. Evaluation of Firewell and Robertshaw-Fulton miniature mask mounting O_2 regulators during explosive decompression.
4. Combined vibration and acceleration lab studies on animals and human beings.

SPACE

1. Support and conduct biopack, high altitude and space operations.
2. Evaluation of open and closed ecological system.
3. Research on reaction to multiple stresses.
4. Development and test of inflight radiation, heat, cold protection equipment.
5. Laboratory experimentation on biological subjects in operational environments.
6. Development and test of inflight gaseous environmental monitoring instrumentation.

Psychological

AERO	SPACE
1. Pilot training and evaluation under simulated emergency conditions in cockpit mockup on 32′ centrifuge.	1. Research on reaction to multiple stresses.
2. Human engineering analysis of man/machine relationships.	2. Research on sensory deprivation effects.
3. Research to establish criteria for differential selection of air crew and support personnel.	3. Selection, adaptation, and training in artificial life support systems.
4. Effects of vibration on performance:	4. Evaluation of crew performance in artificial life support systems.
(*a*) Psychophysical limits of amplitude and frequency.	5. Monitor capsule development to insure adequacy of human factors consideration in design.
(*b*) Mechanical and sound.	6. Test capsule designs for adequacy and reliability under operating conditions.
(*c*) Muscle tone versus time.	7. By designing simulated capsules establish criteria and specifications for operational capsules.
(*d*) Biochemical studies to obviate preconditioning.	

Authority

Authority for the development of biological support facilities to support range users requirements is inherent in the mission of the Pacific Missile Range. Authority for the development and utilization of physiological instrumentation on pilots operating on the range is inherent in the mission of the Naval Missile Center to test and evaluate guided missile systems.

Authority for the Naval Missile Center to engage in life science programs in astronautics is based on the Chief of Naval Operations requirement.

Facilities

Present facilities at the Naval Missile Center for instrumenting airborne and recovery of physiological data are excellent. Facilities for displaying these data on consoles for real time evaluation are limited. The development of consoles to accomplish this is planned for fiscal year 1961.

Present facilities for laboratory simulation of operational conditions are satisfactory for projects with small animals and capsules. In some cases (vibration, acoustics) the present facilities are adequate for projects with human subjects. The fiscal year 1961 program will modify altitude chambers, and the 32-foot centrifuge for projects with human subjects. The expanded vibration facilities and hot-cold chambers for projects with man-machine combinations will greatly extend the research and development potential of the laboratories.

It is planned to initiate studies during fiscal year 1961 for developing facilities to permit simulation of extended space flights, and, in cooperation with other departments, design, fabricate, and evaluate complete man-machine systems.

The Pacific Missile Range Bio-Science Office obligations to support range users in research and development in space medicine indicate certain firm requirements. There is a current proposal for a mobile animal service facility as an interim measure. Fiscal year 1961 studies leading to permanent facilities which will be adaptable to future requirements are intended. These studies will include biological laboratories on shore, a research hospital at Point Mugu, and conversion of a hospital ship capable of serving island and shipboard operations wherever located.

Without a mission in support of astronautics, the Life Sciences Department would function along lines similar to the plan presented herewith, but the magnitude of effort would be limited to activity in the Navy's missile programs and in support of the range operations requirements as specified in the Bio-Science Office functions. Research and development would still be required in the behavioral sciences, environmental studies oriented to survival and safety, selection and training work in support of fleet needs, and human factors aspects of such other activities as may be programed within the Pacific Missile Range-Naval Missile Center complex.

Services to NASA

Capt. Carl E. Pruett, MC, USN, and Lt. Comdr. Glenn F. Kelly, MC, USN, have been assigned as medical monitors for the Mercury program.

Staff chart

	Scientific personnel				Administrative and technical support personnel				Total
	Officers	Enlisted	Civilians	Total	Officers	Enlisted	Civilians	Total	
Bachelor's degree in—									
Chemistry and graduate of pharmacy	[1] 1			1					
Biology									
Psychology			1	1					
Other (specify): Electrical engineer	1			1					
Master's degree in—									
Chemistry									
Biology									
Psychology	1		1	2					
Other (specify)									
Doctors of medicine	2			2					
General practitioner									
Flight surgeons, 2 [2]									
Other specialties (specify)									
Other doctoral degrees:									
Specify by specialty: Psychology (4); Doctor of Science (1): Physiology (1)	3		3	6					
All others					[3] 1	[4] 4	[5] 1	6	
Total	8			13				6	19

[1] 1 consultant graduate of pharmacy and bachelor of chemical engineering has additional duty with Bioscience Office and Life Sciences Department.
[2] 1 flight surgeon is a qualified naval aviator.
[3] 1 lieutenant Medical Service Corps Administrative and Downrange Support, Bioscience Office.
[4] 4 Hospital men, aviation technician, low pressure chamber operator, Life Sciences Department.
[5] 1 GS–12 Electronic Technician, Life Sciences Department.

Major physical resources

[Square feet of floorspace]

	Present (fiscal year 1960)	Future (fiscal year 1961)
1. Bioscience: Office	400	600
2. Life science:		
Office	1,300	1,400
Shop and laboratory	3,200	[1] 29,200

[1] This refers to part-time use as programed of the new Environmental Simulation Laboratory (26,000 square feet).

Special items of research equipment

Facility	Value	
	Present	Future
Vibration [1]	$346,000	$118,000 plus.
Acceleration [1]	80,000	$100,000 plus.
Acoustic [1]	20,000	$25,000 plus.
Altitude/temperature/humidity [1]	40,000	$340,000 plus.
Climatic/temperature/humidity [1] (completion date August 1960)	900,000	$150,000.
Auxiliary pickup display and recording instrumentation [1]	72,000	$80,000.
Simulated test capsules		$700,000.
Monitoring consoles		$150,000.
Low pressure chamber		

[1] The facilities listed are those which are presently used for the laboratory test and evaluation of guided missiles systems and components. They are considered equally useful in conducting environmental studies on animals and in some cases on humans when appropriately modified. The existing facilities are to be relocated to the newly constructed environmental simulation building.

A monitoring console will be one of the additional tools required in employing these facilities for physiological and psychological studies. The simulated capsules will provide test beds for the evaluation of new ecological subsystems and personnel performance under the simulated operational conditions of pressure, shock, vibration, acceleration, and temperature.

FISCAL DATA

See the fiscal table at the beginning of the Department of the Navy section.

Fiscal year 1961 budget item, "Monitoring Consoles"

1. Real time data display of physiological, cabin, and pressure suit functions during instrumented operations on the range and in the environment simulation laboratory is required. A properly configured data display system will enable the personnel monitoring the state of the subjects under test to make continuous and rapid evaluations of the test environment and its effect on the subject.

2. Funds are requested to configure one console for operation with aircraft and another for operations in the environment simulation laboratory.

2. Biological and Psychological Sciences Divisions, Office of the Assistant Chief for Research, Office of Naval Research, Washington, D.C.

This Office was established by the Chief of Naval Research in accordance with Public Law 588, 79th Congress, the establishment of the Office of Naval Research.

The mission of the Office of Naval Research is as follows: * * * The Chief of Naval Research shall conduct research in augmentation

of and in conjunction with the research and development conducted by the respective bureaus and other agencies and offices of the Department of the Navy * * *.

The mission of the Office of the Assistant Chief for Research includes: Plans and directs the Office of Naval Research contract research program to assure maximum advance recognition of the effects of scientific and technological programs to meet the future needs of the operating forces.

Current major programs

1. Stress physiology

This program provides information for the protection and the improved performance of personnel under adverse conditions. Such information as accrued from determination of human capabilities and limitations, physiological studies of circulation, respiration, and temperature regulation; indicies of stress, fatigue, and performance; mechanisms of adaptation and acclimatization; and analysis of the mental and physical impairment produced by these operational and environmental stresses.

2. Regulatory physiology

This work comprises a spectrum of investigations on the mechanisms of reception integration, transmission of information and behavioral responses, and on the conversion, storage and utilization of energy for important life processes, such as growth and wound healing, work output, and mental activity. This is a rapidly advancing frontier of biological science.

3. Toxicology

The objective of this work is to obtain basic information on the action of toxic materials on biological organs or systems with the ultimate aim of developing new and better procedures for toxicological evaluations.

4. Microbiology

This work is designed to provide information in various areas of microbiology for the development of more effective methods for the control of microbial agents. The objectives are to: (1) devise improved measures such as immunizing agents, antibiotics and chemotherapeutic substances for protection against agents of infectious diseases; (2) determine the mode of action, and develop means for control and utilization of micro-organisms of importance in Naval environments; (3) determine and develop microbial chemical reactions that may result in products of importance to naval operational requirements; (4) devise and improve procedures for the detection and identification of microbial agents in the atmosphere and elucidate factors involved in their transmission, viability, and pathogenesis.

5. Biochemistry

Acquisition and application of biochemical information to operational problems involving human, marine life, disease vectors, and agents and other useful or harmful forms of life are sought. Objects of special attention are protein structure and formation; hormones and their activity mechanisms, structure, and activity mechanisms in enzymes. These substances and mechanisms are common to all forms of life in the earth.

6. Biological orientation

This comprises a spectrum of investigations of the mechanisms employed in the reception, integration and transmission of information stimuli, as well as the behavioral responses to these stimuli. Using a variety of biological organisms which exhibit orientation and navigational phenomena as models. Investigators on this project are endeavoring to characterize by means of cytological, physiological, biophysical, and ecological means the cellular, tissue, organ, and systems components, and their interrelationships in orientation and locomotory behavior.

7. Biophysics

The object of the work is to acquire information on problems which involve interactions between physical phenomena and biological systems. Examples of such problems are the exposure of personnel to abnormal amounts of noise, radiation, heat, and pressure; the nature of forces controlling structural configuration of biological molecules; energy transfer mechanisms, and the use of physical principles in understanding the nature and origin of life.

8. Medicine and Dentistry

This subproject will provide information at both the fundamental and clinical levels which will lead to the improvement of means for the prevention and control of disease. Improved methods for the treatment of disease and injury will be developed.

9. Sensory mechanisms

This program includes research on the minimal and optimal physical stimuli, i.e., light, sound, body displacement, etc., capable of eliciting a response under specified conditions. The physiology and function of the receptor end organ, the initiation of the neural impulse, awareness of the stimulus field and, finally, the responses to varying stimulation are subject to analysis. These investigations augment knowledge concerning the normal functioning of human sensory systems as well as their fluctuation under systematically varied conditions of the individual and the environment.

10. Perception and orientation

The objective of research under this program is to obtain quantitative data on the nature and operation of the factors involved in perceptual responses to objects spatially and temporally related, and to signals, messages, or communications presented in visual, auditory or other forms. Additional investigations under this program are concerned with the perception of body motion, orientation in space in the absence of visual cues and the adjustments made by the body under conditions of conflicting cues as to motion and body position.

11. Neural basis of behavior

Investigations are concerned with the function of the nervous system and its integration with other components of the body structure. The primary objective is to determine the relationship between specific neural activity and various patterns of behavior, e.g., learning and memory, psychomotor activities, and work performance under normal conditions and also under conditions of stress, result-

ing from extension of operational and human tolerance limits or unusual environmental conditions.

12. Response mechanisms

The research involves the determination and consideration of such factors as the sensory capacities, motor skills, body strength, physical dimensions, and perceptual and mental abilities of operating personnel. The objective is to provide the basic behavior data necessary for application to the design, production and operation of military equipment which will make maximum use of the operator's skills and consonant with his physical and psychological capacity.

13. Basic traits

Research on the isolation and measurement of basic human characteristics is designed to extend fundamental knowledge of intellectual and personality traits. The objectives are to describe the intellectual functions involved in such areas as verbal, numerical, spatial, and mechanical abilities; to isolate and measure the skills of reasoning, productive thinking, planning, and judgment; and to extend knowledge of and techniques for measuring personality and other nonintellectual aspects of behavior.

14. Selection problems

Research on selection and classification problems applies knowledge about basic human behavior traits for predictive purposes and in general is aimed at specific personnel utilization objectives. The overall objective of such a research program is to improve established techniques for assessment, selection, and classification of personnel and to develop new techniques for these uses.

15. Billet classification

The purpose of this program is to furnish the necessary basic data for other personnel research, training research, and occupational classification. Research in this area also contributes to the development of realistic manpower requirements and the discovery of new methodologic approaches and techniques.

16. Performance criteria

The goal of criterion research is to develop objective measures against which selection, classification, and training procedures can be validated. The measures may be obtained by means of a variety of techniques, such as utilizing production records, achievement of performance examinations, ratings, check lists, etc. Their worth is generally proportional to the degree to which the measures reflect proficiency of performance in the actual behavior for which one is attempting to predict or to train.

17. Training and education

Research on problems of training and education is concerned with human learning and forgetting as these affect task performance and the determination of the conditions which, in one way or another, affect these functions.

18. Group effectiveness

This program views the group as the unit for study. It involves the investigation of those variables which either enhance or detract

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from group effectiveness and the development of measures of team performance.

19. Individual effectiveness

The formation of efficient harmonious teams depends on: (1) Having reliable and sensitive methods of measuring group objectives, structure, process, satisfaction, and productivity; (2) selecting and assigning members who are able and willing to play roles which will be available to them in the task situation and who will find their role playing facilitated by the members with whom they will have to work; (3) establishing and maintaining motivating conditions which will facilitate the emergence of leadership, cooperation, and otherwise effective interaction under stress as well as nonstress conditions; (4) training members to work together effectively; (5) manipulating conditions in such a way as to raise productivity, increase group identification and produce acceptance of new working conditions. The objective of this project is to investigate variables related directly to items (2), (3), (4) and (5) above. A different program is concerned with item (1).

20. Human engineering

The overall objective is to provide the design engineer with data and principles of human behavior which can be used in the design of military man-machine systems. The end-products are reports, handbooks, bibliographies, and compendia of research information.

21. Disturbed mental states

The project aims to determine the nature and predisposing conditions of disturbed psychological states, and to develop predictive instruments and remedial techniques for these disorders.

22. Submarine habitability

The requirements must be determined for man's existence and efficient performance in a vehicle isolated in the ocean. Some of the factors which must be investigated in this determination are: atmospherics and toxicology, environmental factors, and possibly others. Only after determining the nature of the overall requirements of man can a program be organized for providing him with his needs. It is anticipated that the results of this research will be directly applicable to the environmental problems connected with space flight.

23. Integrated command control

This program seeks to increase the effectiveness of naval craft by decreasing crew and training requirements, reducing operational and logistic costs, and increasing the performance efficiency of operating personnel. The program consists of feasibility studies including human engineering and systems engineering. Full integration of all functions necessary for the exercise of command control is a primary objective of this program.

Future major programs

1. Stress physiology

The distribution of effort among the several evironmental and operational stress factors is expected to remain at about the same proportions. Increased emphasis will be placed on the study of the

fundamental physiological processes involved in stressor effects at the subcellular, cellular, and tissue levels of organization. Effort will continue to promote liaison among physiologists and laboratories doing related research. Information obtained which is applicable to stress situations will be made available to appropriate agencies.

2. Regulatory physiology

It is hoped to expand the present regulatory physiology program to include research on the comparative physiological aspects of regulatory systems. In this way, by studying the evolutionary pathways of regulatory systems, a fresh insight into present concepts or even the development of new concepts regarding basic physiological phenomena can be obtained.

The physiology branch will continue its efforts to promote liaison among Government laboratories and contractors working in regulatory physiology and related fields.

3. Toxicology

The accumulation of toxicological data pertinent to the Navy's research and development program will continue. Research, designed to provide improved procedures for evaluating toxicity, will be continued and expanded.

4. Microbiology

Effort will be continued toward elucidation of fundamental physiologic mechanisms of bacteria, viruses, protozoa and fungi in their relationships with each other and to their human and animal hosts, and the effects of chemotherapeutic agents on them. Research into the mechanisms of disease production will be stressed and additional work is planned for the development of improved measures for prevention and control. The problem of the relation between nucleic acid and protein synthesis in bacterial cells will receive attention in work designed to produce a system capable of carrying all the stages of protein synthesis. Studies on the genetics of microorganisms will be emphasized in attempts to solve problems concerned with variation of virulence and resistance to antibiotics and other protective agents. In the areas of marine microbiology, investigations will be directed toward such basic problems as productivity of the sea in relation to microscopic organisms utilizing the chemicals and soluble nutrients of the sea and to factors involved in deterioration and decay of naval materials. Extension of studies on lignicolous salt water fungi will include strength test studies in relation to pertinent physiological and morphological characteristics of the fungi.

5. Biochemistry

The research described under this project will be continued, emphasizing, especially, protein chemistry, enzyme kinetics, and the metabolism of less intensively studied elements such as sulfur.

6. Biological orientation

It is expected that further information will be obtained on the mechanisms of both the time and direction sense in animals which may prove to be a basis for the development of mechanical or electronic analogues in guidance systems.

7. Biophysics

The accumulation of physico-chemical data on peptides will continue and will be extended to proteins. The relation between these data and the functional behavior of the protein, e.g., hemoglobin, will be sought.

8. Medicine and dentistry

The problem of finding the most efficient and satisfactory means for the preservation of whole blood and blood components will continue to be emphasized because of the urgency involved. To this extent, increased support is being given to a research program wherein liquid nitrogen is being utilized as the refrigerant for long-term storage of whole blood.

Considerable effort will be devoted to the general problem of tissue preservation and transplantation. Specifically, more attention will be given the enormous problem of induced tolerance and "tissue compatability," particularly from the immunochemical and genetic standpoints since these areas contain the key to the predominant factors which govern the "take" or "rejection" of homo- and heterographs.

Studies concerned with environmental conditions such as cold weather, pollutants, and others which affect the health of personnel will be continued. Upper respiratory pathology and physiology will be continued. Fluid and electrolyte balance in stress will be emphasized, particularly in relation to the treatment and management of burns, postoperative trauma and other stresses.

The primary concern of the dental research program will continue to be the control and/or prevention of dental caries and periodontal disease. Emphasis will be placed on elucidating the mechanism in tooth metabolism, the pattern of tooth decay, and the external factors in the mouth or in physiologic processes which predispose this tissue to decay or in some way influence it. The study of the role of oral tissues, fluids, and substances in the oral environment in the defense against these diseases will continue. Minor phases of the program such as studies for improving restorative materials and radioisotopes for radiographs will continue.

9. Sensory mechanisms

This program is structured to provide scientific coverage of the broad field of the sensory systems from the delineation of appropriate physical stimuli, through the receptor end organ, the afferent system and finally the response at the cortical level of the brain.

It is anticipated that those tasks previously concerned with high level jet noise will direct their attention to discontinuous blast type noise and also the acoustic characteristics of rockets, missiles and space vehicles.

10. Perception and orientation

The research program during the coming year will provide a dual approach to the problem of perception. On the one hand those tasks which are directed toward concentrated study of the structure, mechanisms, and limits of the perceptual system within a single sense modality will be continued. On the other hand, effort will be directed toward studies of the interaction or interdependence of the sensory systems in determining perceptual efficiency, as represented by studies

of sensory isolation, perceptual response in a homogeneous field, and the stimulus analyzing or coding mechanism at the cerebral level.

11. Neural basis of behavior

The multidisciplinary approach encouraged under this program will be continued. Particular stress during the coming year will be put on studies concerning the influence of drugs on human performance efficiency. Behavior studies will be initiated to investigate the use of drugs in terms of their influence on the mitigation of work decrement, enhancing a particular aspect of performance, delaying the onset of fatigue and other effects which might permit military personnel to function more efficiently. It is anticipated that research will be undertaken concerning electroencephalographic and microelectrode recording from the visual cortex.

12. Response mechanisms

It is anticipated that the U.S. Naval School of Aviation Medicine will continue to assume increasing responsibilities for certain of the profitable research activities initiated under this program with particular reference to operational evaluation of communication techniques and noise protective devices.

Increased emphasis will be placed upon research dealing with human performance under conditions of whole body vibration. These studies will not only include physiological and psychological measures but also evaluations of various control-display relationships which may reduce performance impairment under conditions of vibration and stress.

13. Selection problems

Methodological studies, such as the explorations in the area of differential prediction and the research on test theory will continue. Test development will be undertaken in line with the dictates of service needs. As fundamental traits are identified in the research on basic psychological traits, techniques for their measurement will be undertaken in appropriate cases. Experimental tryout, refinement, and validation of currently developed tests will proceed where necessary. A shift in research emphasis is anticipated in the coming year as a result of a changing trend in the way in which personnel selection is viewed. There is an increasing tendency to view personnel programs as systems with selection, training, etc., considered to be subsystems within the larger whole. Changes in research approach are anticipated as a result of this new concept.

14. Billet classification

Future efforts in the billet classification and analysis domain will be directed toward the formulation of a general conceptual framework intended to provide the basis for describing jobs in general. There is a great need for work in this area since so many personnel and training decisions within the military are dependent upon the accuracy of job descriptions. Many of the currently available descriptions are situation-bound and suffer from the fact that they are produced during preliminary stages of weapons development and are necessarily based on speculation or superficial knowledge of the skills involved. A taxonomy of tasks will provide a set of common param-

eters which can be used to describe any job in psychologically meaningful terms. In addition to the initiation of research aimed at defining basic job parameters, a comparative evaluation of the available methods for collecting job descriptions will be conducted.

15. Performance criteria

The broad program of research on human factors problems in ASW, antisubmarine warfare, will continue. Emphasis in the coming year will be on experimental studies of sonarman training aimed at increasing classification proficiency. Basic work on target detection (vigilance) will continue as will the research on target classification, specifically on rotational directional transmission modified sonars. The Electronics Personnel Research Group will continue their program in two large interrelated areas; the use of electronics equipment in naval operations, and the maintenance and repair of this equipment. The criterion problems of the aviation technical rates will continue to receive research attention and new tasks will be undertaken as personnel research in new weapons and related developments bring criterion problems to light. The initiation of effort aimed at objectifying the evaluation of fleet exercises, particularly ASW exercises, is also planned.

16. Training and education

Research in human learning pointed toward the eventual establishment of the optimal conditions for learning will continue to receive support. Training research, or studies in the applied psychology of learning, will continue. A task is being initiated which is aimed at clarifying some of the issues involved in the increased use of the so-called learning machines or automated tutoring devices. This will be directed at basic learning issues rather than on demonstrations of the teaching effectiveness of such devices. It is anticipated that the initiation of research on personnel systems will affect somewhat the direction of the training research of the project.

17. Group effectiveness

There will be increased attention to group problem solving, extending research into the area of linguistic and logical analysis of problem solving processes and machine simulation of the interaction involved. Such analysis will be used for purposes of theory building.

A new area of interest will be the study of the interrelationships of groups as units. Pairs of groups will be placed in a mutual problem situation and their responses studied under various conditions.

Work will continue on effects of group composition and structure on interaction, mathematical models of group behavior, communication patterns under various task conditions, and personal needs in group situations.

18. Individual effectiveness

Considerable effort will continue to be devoted to analysis of the place of attitude change in the process of concept formation and alteration of belief systems. Effects of personality differences on such processes will also be determined.

Also continuing will be work on the leadership position as it relates to the leader's attempts to influence, his acceptance by followers, and his true task effectiveness as contrasted with popularity. A new

emphasis will be manipulation of rewards for leadership attempts, to determine whether such reinforcement increases the display of leader behavior.

Study of social perception will increase and be extended into the area of perception of other cultural groups.

19. Human engineering

The long-range program of improving communications and providing the design engineer with human engineering assistance and data will be continued.

20. Submarine habitability

Research into the ramifications of a human being in a closed space environment will continue.

21. Integrated command control

Additional research and development in support of the objective of this program will be recommended as a result of the requirements and capabilities disclosed in preliminary studies.

Authority for present and anticipated future programs.—Authority rests with the Basic Public Law, Secretary of the Navy Instructions and Operational Requirements.

Suitability of present and planned facilities to the current and assumed future missions of your organization.—Not applicable.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services?—This organization has a basic mission to meet Navy requirements as specified above. Current and planned programs are related and do contribute to aeronautical and space sciences but have been established to support requirements of the naval forces.

FISCAL DATA

Budget estimates for present and future programs, fiscal years 1960–61

[In thousands]

	Fiscal year 1960	Fiscal year 1961
Stress physiology	$200	$100
Regulatory physiology	100	100
Toxicology	25	25
Microbiology	80	80
Biochemistry	75	60
Biological orientation	30	20
Biophysics		25
Medicine and dentistry	20	20
Sensory mechanisms	10	10
Perception and orientation	20	15
Neural basis of behavior	20	20
Response mechanisms	20	15
Basic traits	5	10
Selection problems	10	10
Billet classification	0	0
Performance criteria	15	20
Training and education	30	30
Group effectiveness	20	15
Individual effectiveness	25	20
Human engineering	15	5
Submarine habitability	0	35
Integrated command control	700	800
Total	1,430	1,435

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories.—Entire program is by contract.

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at inhouse facilities for other Government agencies.—Not applicable.

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies.—None.

Major physical resources.—Not applicable.

Staff breakdowns—Psychological Sciences and Biological Sciences Divisions combined

	Scientific staff			Administrative and technical support staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of philosophy	1	11	12				
Master		2	2		2	2	
Bachelor of arts					4	4	
Administrative assistant					1		
Secretary					11		
Stenographer					1		
Total			14		19	6	30

3. U.S. Naval Research Laboratory, Office of Naval Research

In accordance with the recommendations of the Naval Consulting Board and by Act of Congress there was built at Bellevue, D.C., a Naval Research Laboratory which was formally opened July 1, 1923.

Mission

Under the direction of the Chief of Naval Research, the mission of the Naval Research Laboratory is to conduct scientific research and development in the physical sciences and related fields directed toward new and improved materials, equipment, techniques and systems for the Navy. In fulfillment of this mission, the Naval Research Laboratory:

(1) Initiates and conducts scientific research and development of a basic long-range nature in scientific areas of special interest to the Navy.

(2) Performs scientific research and development for the Bureaus and Offices of the Navy and, where specially qualified, for the Defense Department and, in defense related efforts, for other Government agencies.

(3) Furnishes scientific consultative services for the Navy and, where specially qualified, for the Defense Department and, in defense related efforts, for other Government agencies.

(4) Provides limited engineering test and evaluation services to the Navy.

Engineering psychology

The overall objective of this research is to study the basic psychological factors which underlie human performance in man-machine systems and to provide a set of psychological principles on the basis of which optimum system characteristics may be developed.

Personnel protection against toxic atmosphere and fire

Studies of measures to insure atmospheres safe for breathing.

Future programs

Same as above.

Authority for programs

The Director of the Laboratory has delegated responsibility for the initiation and acceptance of research programs to the Laboratory's Research Advisory Council. This Council is composed of the Director of Research and the three Associate Directors of Research.

Suitability of facilities

An architect and engineering study has just been completed to provide new facilities for the current research program and for anticipated future requirements.

FISCAL DATA

Budget estimates (in thousands of dollars)

	Fiscal year 1960	Fiscal year 1961
Engineering psychology	222	233
Personnel protection	342	393

Grants and contracts: None.

Capital investment in overall plant and equipment is $1½ million through fiscal year 1959; $30,000 in fiscal year 1960; and $30,000 in fiscal year 1961 will be added.

Present and anticipated future services or project awards to other Government agencies or performed at inhouse facilities for other Government agencies.—None.

Staff breakdown

	Scientific staff			Administrative and technical support staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of Philosophy:							
Biology							
Psychology		2					2
Physiology							
Biochemistry							
Chemistry		5			5		10
Physics		1			1		2
Doctor of Medicine:							
Doctor of Medicine: General							
Flight surgeon							
Other specialists							
Other doctoral degrees: None.							
Master's degree:							
Electrical engineer		1			2		3
Mathematics		1			2		3
Chemistry		4			6		10
Psychology		2			4		6
Bachelor's degree:							
Chemistry		6			5		11
Physics		1					1
Psychology		2			2		4
Education		1					1
Mathematics		1			3		4
Total		27			30		57

Currently, there are no U.S. Naval Research Laboratory personnel on loan to other Government agencies nor are personnel from other Government agencies on loan to this activity for work in these fields. However, attention is invited to the fact that this Laboratory provides extensive consultative service not only to members of the Department of Defense but to other activities as well.

Major physical resources

5,600 square feet.

Special laboratory facilities

None. Regular laboratory facilities are used for these programs.

Special items of research equipment

Mass spectrometer, infrared spectographs, an experimental combat Information Center facility, air-conditioned areas for atmosphere work, analog computer.

4. U.S. Naval Training Device Center, Office of Naval Research

The U.S. Naval Training Device Center, formerly a division of the Bureau of Aeronautics, was later reassigned as a division of the Office of Naval Research (formerly Office of Research and Invention).

> Its mission, under the direction of the Chief of Naval Research, is to contribute to the Navy's operational readiness by improving the effectiveness of the naval training program through the conduct of research leading to, development of, and production when assigned, of training devices, to fulfill the established requirements of the training agencies; to provide logistic support for training equipments

developed by it; to study training problems as they may relate to training devices and recommend solutions, training techniques, and systems; to perform such other tasks as assigned by the Chief of Naval Research.

Current major U.S. Naval Training Device Center programs for study on biological, medical, and psychological projects in support of the Navy's aeronautical and space programs:

(1) Engineering psychology: The objective of research in this program is to investigate and understand the behavior of man within organizational and machine systems, and to develop the foundations for a sound technology in applied psychology for application to training devices.

(2) Training device components (research and development): This project covers the research and development pertaining to training aids and training device components in the fields of undersea, surface, and air warfare.

Future major programs.—Same as above.

Authority.—Chief of Naval Research.

Suitability of present or planned facilities.—Present facilities are adequate for work programed through 1965. Planned modifications to existing Government facilities planned for 1965 are suitable for the conduct of the studies and laboratory work scheduled through fiscal year 1965.

The U.S. Naval Training Device Center's mission includes the conduct of space and aeronautical support studies and the development of research models in support of the Chief of Naval Operations and the Navy Bureaus life sciences research and development programs. Further, when directed by the Chief of Naval Research, and within the availability of suitable physical and human resources, to undertake life sciences projects requested by the Army, Air Force, and the National Aeronautical and Space Agency.

FISCAL DATA

[In thousands]

	Fiscal year 1960	Fiscal year 1961
Engineering psychology	79	150
Training device component	67	15

Included in above (costs of present and anticipated grants and contracts).

Capital investment assigned to above listed programs, $125,000.

Awards to other Government agencies.—

None.

Number of personnel on loans—None.

Major physical review

Square feet of floor space: 3,000 square feet.

Special laboratory facilities: None.

Special item of research equipment: None.

Staff breakdown

	Scientific staff			Administrative and technical support staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Doctor of philosophy: Psychology		3					3
Master's degree (specify)		MEE 1					
		MIE 1					
		MA (Psy) 1					3
Bachelor's degree (specify)		BEE 1					
		BS (phy) 1					2
All other personnel		1			3		4
Total		9			3		12

5. U.S. Naval Medical Research Institute, National Naval Medical Center, Bethesda, Md.

The Naval Medical Research Institute was commissioned as a component command of the National Naval Medical Center on October 27, 1942, with an initial staff of 13 officers and 50 enlisted men. The mission of the Institute is to conduct research contributing to the improvement of the health, safety, and efficiency of naval personnel. During the years, the Institute was enlarged to approximately four times its original size and currently has a staff of 284 military and civilian personnel. The specific functions of the Institute are: To conduct research in fields of importance to naval medicine, to furnish consultative and advisory service to other naval activities, to train qualified personnel in research methods, and to maintain a nucleus of qualified personnel and suitable facilities for expansion in time of national emergency.

Current major programs applicable to aeronautical and space activities

(1) *Radiation.*—This program is primarily concerned with the application of basic concepts in research to the measurement and evaluation of radiation effects upon the living cell and the entire organism, protective measures against ionizing radiations, and to a correlation of these factors. The institute divisions contributing to this area of research include Radiation Technology, Pathology and Pharmacology and Radiation Biology, and Physiology.

(2) *Environment.*—The research programs in this area are primarily of a basic and applied nature to problems relating to physiological effects in man both in normal and in abnormal (extreme) environments. The relation of these programs to bioastronautics is most obvious in situations of thermal stress, human metabolism and energetics; i.e., heat production, heat storage and heat loss, human performance and efficiency, and physiological and pathological responses to abnormal concentrations of natural and unnatural atmospheric components. The divisions contributing to this area of research include Bioenergetics and Physiology.

(3) *Acceleration.*—This program represents a major effort pursued by the Biophysics Division of the Institute. It is primarily oriented to derive basic knowledge on the physiological and pathological effects

of vibration. Relevence to bioastronautics is based on knowledge that intense vibrations occur during certain phases of missile operations. The likelihood that these mechanical forces will be coupled to the occupants of a space vehicle may alter the latter's performance, or may cause injury.

(4) *Monitoring.*—This work area is being carried out by the Aviation Medicine Division and currently represents the prime interest of that division. Active work in this area dates back to 1947. Rapid developments in the field of electronics have enabled the personnel engaged in this work to carry on a continuing program of refinement as well as the design and fabrication of original models of physiological telemetering equipment.

(5) *Metabolic cycles.*—Many of the Institute's research programs pertain to studies of the metabolic processes that take place in biologic specimens as a whole or in their various component tissues. The overall program is broad and highly diversified. The projection of man into space must of necessity provide for his sustained performance within his capsule. Economy of effort dictates that as many of man's metabolic needs as possible be recovered from his bodily waste products. Recognizing this, the Chemistry Division of the Institute recently developed a relative easy system of recovering potable water from urine.

Future major programs

Further expansion of any of the existing programs to develop promising and productive research along specific areas of interest to bioastronautics will require additional funding and personnel. This consideration is necessary since budgetary restrictions exist and programs of research of pertinent relevance to the overall naval military picture need to be maintained in appropriate perspective. The extent of such augmentation can only be determined after an overall medical research program in bioastronautics has been defined and assignments of the tasks are distributed to appropriate facilities. Areas where augmentation of our current programs are desired include further refinements of telemetering equipment for the transmission of biological data and the procurement of high-speed X-ray equipment of approximately $50,000 value to demonstrate interior vibration effects on biological specimens including man. The Radiation Center of the National Naval Medical Center will be greatly augmented during the next 18 to 24 months by the acquisition of a large nuclear reactor and linear accelerator sponsored by the Defense Atomic Support Agency and under management control of the Bureau of Medicine and Surgery and the completion of the Radiological Exposure and Evaluation Laboratory (REEL) which will be under the management of the Naval Hospital command.

Authority for present and anticipated programs

Military requirements as promulgated by the Chief of Naval Operations.

Suitability of present and planned facilities for the current and assumed future missions

With the exceptions stated in the preceding subparagraph (d) existing facilities are adequate for present and assumed future research programs and future mission in support of manned spacecraft.

Other roles in the absence of a mission in support of astronautics

The overall research program of the Institute includes basic and applied research in a wide variety of fields of importance to naval military medicine. Each member of the scientific staff is highly specialized and collectively they have capabilities in many fields of endeavor. These capabilities are now being exercised in important and productive projects which may at any time uncover principles or products of importance to aeronautical and space activities. With its wealth of specialists in various research areas, the Institute can also be of assistance in providing consultative and advisory services to special situations and train qualified personnel.

FISCAL DATA

See the fiscal table at the beginning of the Department of the Navy section. It can be added that the research program of the Aviation Medicine Division is most applicable to the aeronautical and bioastronautical program and budget estimates for their specific program are $45,000 for fiscal year 1960 and $77,000 for fiscal year 1961. However, these Aviation Medicine Division budget estimates do not include costs additionally borne by the ONR and the Bureau of Weapons for the maintenance and operation of the project RAM plane and the travel expenses of personnel engaged in project RAM research activities. RAM stands for "Research, Aviation Medicine" and pertains particularly to an airplane that is instrumental to permit telemetering of physiological data to ground stations from experimental subjects in flight.

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions, by major categories

None.

Capital investment in overall plant and equipment, both at present and anticipated for future

	Present investment	Future investment
Plant	$3,365,802.79	$3,365,802.79
Equipment	1,556,300.42	1,646,300.00
Total	4,922,103.22	[1] 5,012,102.79

[1] An increase of $89,999.57.

The percentage of above investments applicable to aeronautical and space activity is approximately 9 percent.

Description and costs of present and anticipated future services or project awards to NASA for performance, or performed at inhouse facilities for NASA.—At the present time this Institute is not furnishing any services to NASA in response to a specific request for services or project award. However, all research reports relating to the field of aeronautics and space activities are available to NASA.

Numbers and types of personnel on loan to other Government agencies or on loan from other governmental agencies.—None.

Numbers and types of personnel on loan to other Government agencies or on loan from other governmental agencies: None.

Major physical resources

Square feet of floorspace	147,938
Square feet above designated as research laboratory space	49,100
Square feet utilized in research effort applicable to aeronautical and space activities	4,420

Special items of research equipment

1. Human gradient calorimeter (bioenergetics division).
2. Diving unit, pressure chamber, recompression chamber with controlled atmosphere and controlled atmosphere compartment (subdiving branch of physiology division).
3. High altitude refrigerated chamber (aviation medical division).
4. Telemetering equipment (aviation medicine division).
5. Cobalt irradiator (radiation technology division).
6. Vibration apparatus (biophysics division).

Staff breakdown

	Scientific personnel				Administrative and technical support personnel				Total
	Officer	Enlisted	Civilian	Total	Officer	Enlisted	Civilian	Total	
Bachelor's degree in—									
Chemistry		1	3	4					4
Biology		2	2	4	1			1	5
Bacteriology	1		1	2					2
Parasitology			1	1					1
Physics	1		1	2					2
Engineering (electrical)	1			1			1	1	2
Library science							1	1	1
Agriculture		1		1					1
Mathematics					1			1	1
Master's degree in—									
Chemistry	1		1	2			1	1	3
Biology			1	1					1
Psychology	1			1					1
Anatomy			1	1					1
Education			1	1					1
Zoology			1	1					1
Entomology			1	1					1
Bacteriology	2		1	3					3
Philosophy							1	1	1
Doctors of medicine:									
Specialties:									
Bacteriology			1	1					1
Physiology	2		5	7					7
Pathology	3			3					3
Radiation biology			1	1					1
Virology	1		1	2					2
Surgery	2			2					2
Biochemistry	1			1					1
Biophysics	1			1					1
Tissue immunology	1			1					1
Submarine medicine					[1] 1			1	1
General practitioner	2			2					2
Flight surgeons	[2] 4			4					4
Dentistry	2			2					2
Doctors of science:									
Specialties:									
Parasitology	1		2	3					3
Physiology			1	1					1
Doctors of philosophy:									
Specialties:									
Chemistry	1		6	7					7
Physics	1		2	3					3
Physiology	2		1	3					3
Entomology	2			2					2
Virology			1	1					1
Immunology	1			1					1
All others		98	28	126	4		75	79	205
Total	34	102	64	200	7		79	86	286

[1] C.O., NMRI.
[2] 2 are assigned on an additional duty basis from other naval activities.

6. U.S. Naval Medical Research Laboratory, Submarine Base, New London, Conn.

The medical research activities at the U.S. Naval Submarine Base were formally organized in February 1944, with the designation of a Medical Research Department as a separate department of the submarine base. Until that time it had been functioning informally as a segment of the Base Medical Department.

In June 1946, the Secretary of the Navy established a U.S. Naval Medical Research Laboratory, under the direction of an officer in charge, as a subordinate activity of the submarine base, and under the management and technical control of the Bureau of Medicine and Surgery. At that time, the mission of the Laboratory, as stated in the Basic Naval Establishment Plan, was "To conduct medical research and development in submarine, shipboard and diving medicine." The mission of the Laboratory was revised by the Secretary of the Navy in February 1959, and is now stated as follows: "To conduct medical research, development and training of medical personnel in submarine, shipboard and diving medicine." This change in the original mission provides for the training functions which this activity performs; i.e., (*a*) the training course for prospective submarine medical officers; (*b*) the training course for prospective submarine hospital corpsmen; and (*c*) the course for medical officers and hospital corpsmen in health physics, required for duty in nuclear-powered submarines.

Participation in Bioastronautics Program of the Bureau of Medicine and Surgery (Current and Future)

1. Radiation

(*a*) Nuclear: NMRL is closely associated with the Nuclear Power School since the head of that school is a member of the Laboratory staff and conducts the training of hospital corpsmen who are to be assigned in the nuclear-powered submarines. On the Laboratory side is also an isotope research unit.

(*b*) Spectral: Qualified personnel in the Laboratory facility can be used for this aspect, studying the effects of excessive sunlight above the earth's atmosphere. NMRL has qualifications in the measurement of optical media for protective density characteristics.

2. Environment

(*a*) Toxic: Present status. Research on toxic elements in closed air spaces occupied by human subjects. Identification and tolerance limits of a variety of substances.

(*b*) Noise. A many-sided attack on the effects of high intensity noise on the human ear and the provision of protective measures. Modern sound suite—anechoic and reverberant chambers supported by many specialized pieces of electrical equipment existent.

(*c*) Physical: Human enginereing approach to physical aspects of habitability of the vehicle, providing for duty watch and for rest and recovery in a many-sided attack to the problem as related to submarines. Accessibility to new mockups as developed at Electric Boat Division of General Dynamics in the planning of ships under construction.

(*d* and *e*) Physiological and Psychological Aspects of Respiratory Problems: A major portion of NMRL's program has been devoted to determining the optimal atmosphere which may be supplied for confined spaces. Monitoring for submarines, etc. Definitive results have been achieved in relation to the carbon dioxide content of the atmosphere. Physiological aspects.

(*f*) Visual: NMRL has a major effort to define the visual requirements for operation of controls and the making of observations. These requirements concern the amount of light and visual qualifications of the operators.

(*g*) Temperature. The relation of temperature to habitability and to performance is of research interest in its physiological and psychological aspects, but not a major problem.

3. Selection and training

Our Selection and Training Branch has many years' experience in the development of criteria for selection of submariners and in defining the characteristics of men who can endure prolonged isolation while on their military duty. NMRL assumes a considerable parallel in the problems presented in the selection of astronauts.

4. Survival

Recovery. NMRL has been organized to participate in the planning for the recovery phase of the capsule in Project Mercury, specifically, the preliminary practice of escape from the capsule after it lands in the water. The physiological and medical aspects of underwater escape are a specialty field of this Laboratory.

5. Permormance

NMRL is interested in learning about the actual performance achieved in bioastronautics, but at the present is not specially equipped to undertake any considerable work effort in this field.

6. Metabolic cycles (life support systems)

The maintenance of personnel in enclosed spaces, whether for several hours or several days, poses many problems (food, water, excreta, etc.) in which NMRL takes interest. Project Hideout (1952–53) for 60-plus days' duration brought into view many of these problems. (This was a simulated, long submergence cruise). A large compression-decompression chamber is about to be constructed in the Laboratory. This will offer a primary facility for work on problems within this domain. NMRL expects to have a very effective program of this character, beginning probably 9 months from now.

7. Space contamination

Contamination of closed spaces can result from a large number of substances and a variety of circumstances. NMRL is concerned with avoiding harmful contaminations in submarine spaces, especially in those cases where submarines are continuously submerged for many days. The nuclear-powered submarines offer special opportunities and challenges in reference to this group of problems.

8. Zero gravity/subgravity states

The large anechoic chamber has a facility wherein a tank of water can be placed, enabling the study of water supported personnel under

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conditions of absolute quiet and general sensory deprivation. NMRL has made some preliminary experiments of this nature with naval ensigns, and could continue this line of investigation.

9. Bioastro-instrumentation and data handling

The elaborate simulation equipment for the handling of submarines and mock-up instrumentation proposed for future vehicles represents strong interest. With the reactivation of the Human Engineering Branch, this area will receive a major portion of NMRL effort.

Staff breakdown

	Scientific personnel				Administrative and technical support personnel				Total
	Officers	Enlisted	Civilians	Total	Officers	Enlisted	Civilians	Total	
Bachelor's degree in—									
Chemistry			1	1	2			2	3
Psychology			3	3					3
Biology									
Other (specify)									
Classics							1	1	1
English							1	1	1
Business			1	1					1
Optometry			1	1					1
Zoology			1	1					1
Master's degree in—									
Chemistry									
Biology									
Psychology			3	3					3
Other (specify)									
Education							1	1	1
Doctors of medicine:									
General practioner					2			2	2
Flight surgeons									
Other specialties									
Submarine medicine			(1)	1	2			2	3
Ophthalmologist					1			1	1
Psychiatrist					(1)			1	1
Other doctoral degrees (specify by specialty):									
Doctor of philosophy									
Psychology			6	6	1			1	7
Experimental psychology			1	1					1
Physiology			1	1					1
Biochemistry			1	1					1
Physiological psychology			1	1					1
Social sciences			1	1					1
Doctor dental surgery	1			1					1
Doctor dental medicine	1			1					1
All others		9	4	13	3	23	19	45	58
Total	2	9	26	37	12	23	22	57	94

Analysis of research work bearing on bioastronautics

The field for research of NMRL in support of shipboard, submarine, and diving medicine has, for administrative convenience, been divided into six sectors or branches. These subdivisions are: Personnel assessment, vision and light, hearing and sound, dental and oral, human factors engineering, and physiology and biochemistry. Analyses of recent research work and of planned investigations are here presented under these six subdivisions.

1. Personnel assessment

(*a*) *Psychological evaluation of personnel for submarine duty; selection techniques research.*—Valid group and individual tests and

other methods for screening men for long cruises have been developed. Functional characteristics of the autonomic nervous system have been found to correlate with emotional stability and general psychiatric status. The current program includes contrived stress situations and measures of ability to recover autonomic equilibrium. Studies of aptitudes and psychiatric variables as possible predictors of adjustment in prolonged submarine submergence conditions or space travel are being conducted. In the future it is planned to attempt to assess intra-individual patterns of reaction to the isolation of long submergence or simulated space orbits. If the psychological factors affected by these stressful conditions can be defined, it may be possible to develop valid predictors for the qualities of total adjustment required for hazardous environmental conditions.

(*b*) *Motivated and group processes research.*—At present this research is focused on assessing the values, interests and attitudes composing the motivational structure found in submariners. A study of the interrelationship of aptitude and general psychiatric status with motivation is being pursued. It is proposed to study the usefulness of motivational data to predict the ability of men to maintain optimal motivation for considerable periods of time in long submergence or other types of isolation. If found valid, the motivational predictors might have applicability to a wider range of stressful conditions, including space orbits.

(*c*) *Stress and fatigue research.*—Data obtained from long submergence cruises and artificially contrived stress situations indicate that monotony and boredom result in autonomic nervous system disequilibrium for some individuals. NMRL has collected such data and is currently collecting data on personnel in Antarctica and on men serving with long-submerged atomic-powered submarines. Accumulation of such data is a slow process; however, from these results, it is hoped to derive some reliable criteria that may help in assessing individuals for duty tours in lonely environments.

2. Vision and light

Generally speaking, man's life and activities at the surface of the Earth depend on his being able to see. The human organism is uncomfortable and feels at a disadvantage if unable to see at least its immediate environment. So great a dependence is placed on sight ranges of adaptability within the bounds of relative comfort. Vision can be used almost continuously for long periods, or, under certain circumstances, can be done without. Even so, sight and visibility are very worthwhile research fields which provide data enabling this information receptor to be used and conserved to the best advantage of a crew's mission and maintenance. The role that vision can play in extended environments, such as long submergence or in space orbits, is a continuing field of research at NMRL. Sight in these circumstances may have a restricted usefulness which becomes increasingly critical.

(*a*) *Psychophysical studies of visual factors in submarine operation.*—Various studies have been accomplished in the field of photopic vision which provide basic information on the effective use of vision in confined spaces. These studies concern patterns and forms under white and colored lights and include both central and peripheral vision.

Studies have been made on sensitivity and acuity under low levels of illumination and represent determinations of the minimal acuity needed for various tasks. Visual characteristics of the interiors of submarines have been surveyed, and this program is continuing. Conferences with industrial representatives are conducted on the visual tasks and provisions for lighting of space capsules. Standards for white and red illumination have been worked out for the submerged submarine to provide adequate acuity for crew performance in the control center and, at the same time, permit maintenance of dark adaptation required for efficient use of the periscope.

As equipment and military mission tasks develop and change, the visual requirements for specific situations must be reanalyzed, revised and adjusted. The present trend toward automation requires that the visual tasks of monitoring be evaluated not only in terms of past standards, but also with regard to the new military decision requirements and expectations. In terms of instrumentation and other aspects, NMRL's section on vision and light has the capability of assisting the program of man in space. Some details of a specifically planned military operation or mission are necessary before the visual requirements and hazards can be assessed and profitably investigated.

3. Hearing and sound

Hearing as an information receptor for signals in man's environment is a continuously operating system (ears have no physiological equivalent for the eyelids). Even during sleep, the auditory mechanism constitutes a relatively open channel to the brain through which attention may be aroused. As a rule, man's environment provides some objective auditory experience. It is rare that a human being finds himself in an anechoic space and such an experience is challenging in its strangeness. A man may guard his ears from excessive sound or noise and, in various ways, may assist them in the detection of faint stimuli. As in the case of sight, so also for hearing does the human organism evolve behavior suitable for a large variety of intensities and qualities of auditory experience within what is called a comfort zone. As social beings, men's personalities usually suffer more from deafness than from blindness. However, as a rule, men can forgo sensory input from hearing at a work task better than from sight. Fortunately, auditory input by electronic means has become a scientific commonplace, but military requirements may restrict the full use of modern facilities. Sonar has become the critical sensory input for submerged submarines. Radio-type communication seems available for men who may be moving in space orbits. Therefore, auditory research must remain an active field of investigation in support of man's missions in these extended environments.

(*a*) *Psychophysical studies of auditory factors in submarine operation.*—Studies under this subtask have dealt with basic auditory abilities in pitch and loudness discrimination, signal detection, speech communication and intelligibility. These studies have been expanded to include the time domain and the performance of continuous monitoring tasks, including the detection of signals in noise during protracted listening periods. Studies have been made on the effect of duration on tone detection and loudness discrimination, and this work is being extended to include identification signals of greater complexity.

(*b*) *Physiology and biochemistry of hearing.*—Substitution of pure oxygen or pure nitrogen for the air in the middle ear has been found capable of markedly altering the cochlear response. Present work is concerned with further investigations of the effects of changing the gases within the middle ear and in the circulating blood. In the best preparations, a mixture of 20 percent oxygen and 80 percent helium was found to alter the size of the cochlear response to a constant tone. Researches of this character seem pertinent to the problems of a small capsule within which gases differing from ordinary air may be used for human respiration. Research has been started on studies of fatigue of the cochlear response and peripheral portions of the auditory nerve following intense stimulation.

4. Dental and oral

Of man's facial features, his mouth is the most expressive of his feelings and emotions. A sense of comfort in this region is a primary condition for his having a sense of normality. Since respiration, ingestion of food and liquids, vocalization, and the use of tobacco and other substances all involve this area, the condition of its several tissues is of personal importance. It is understandable that the mouth may serve as an index of a person's state of health. Oral health is a matter of concern to naval personnel and merits a program for control and improvement based upon active research. The dental branch at NMRL is conducting studies on the oral health of men living in unnatural environments. The oral tissues are studied in relation to general health and as early diagnostic indicators for hygiene problems. The effect of the stresses of submarine service are being examined in these terms. The oral health of personnel in Antarctica is also under an extensive program of investigation. This latter project called Deep Freeze has been in program for about 4 years. During each season of the Antarctic Expeditions, upward of 100 men have been the subject population studied. This program has included dental clinical examinations, histories, bacteriological tests, and electrolyte determinations of the saliva, etc., of wintering-over personnel. Incidental to collecting these data on the oral tissues, much information on psychological aspects of living in the isolation of Antarctica has been freely communicated by these subject populations.

Current studies now in progress in that cold and far-from-home environment include: Determination of vitamin C tissue levels, absolute eosinophil counts observation of tongue patterns under ultraviolet illumination, hematological studies, and the development and testing of a cold-weather protective face mask. Some of these investigations on the effects of cold may be quite applicable to problems of man in space and most certainly the space man will want mouth comfort.

5. Human factors engineering

Tools, machines, missiles, and vehicles are only extensions of man's capabilities and represent his intentions. To consummate these objectives he must comprehend and control these instruments. Human Factors Engineering embodies the idea that man is an essential element in any electro-mechanical, physical, or chemical system subject to his purpose. The man-machine loop is a common term and an es-

sential one in our modern thinking. The successful integration of man with machines seems best achieved by adapting the machine to the man rather than forcing in the opposite direction.

(*a*) *Submarine photometric surveys.*—Assistance and consultations on lighting problems have been given for several submarines during the construction of these ships. A series of specifications have been formulated recommending color treatments, materials and various unit installations aimed at improving habitability through the selection of more safe, durable and pleasant functional arrangements of space and materials. This is a continuing program.

(*b*) *Dial, panel, and work-area design and illumination.*—Studies have been conducted to develop new types of digits and other features of dial designs to eliminate perceptual errors. The problem of optimal configuration for visual warning signals has been investigated. The optimal shape and arrangement of submarine instrument panels and other work areas requires a continuing program of research to keep abreast of other current features of submarine development.

6. Physiology and biochemistry

A space vehicle designed to carry a man or men into an extended environment, whether under water or beyond our habitable atmosphere, must, as a first and primary necessity, provide for the continuance of respiration. The passenger will need a supply of oxygen for which there is no known substitute. He must also be able to maintain his internal body temperature by suitable clothing and an immediate environment that is not too hot or too cold. Periodically he will require food and water. These bare essentials for remaining alive and in a condition able to give attention to instruments, signals, and communications constitute the physiologic framework basic to the whole prospect of outer space travel. If first things should be placed first, here is where to begin—at the anatomical-physiological level. Already a large amount of fundmental research has been accomplished in reference to these elementary problems.

(*a*) *Physiological factors affecting submarine habitability.*—At NMRL a very considerable amount of research accomplished with animals and men has been concerned with the atmosphere components of the submarine environment. This program led to the establishment of the tolerance limits for CO_2, carbon dioxide, which provided the basis for CO_2 removal units in the nuclear-powered submarines. The CO_2 tolerance levels in enclosed systems, such as submarines and space capsules, are fairly well worked out. What the human organism will have to pay or endure for confinement under various levels of CO_2 and durations of lowered O_2, oxygen, is becoming clarified in quantitative terms. The final processing of the data accumulated in previous work and the preparation of these reports are well advanced at NMRL.

Current plans provide for physiological and biochemical studies of free radical formation, ions, and condensation droplets as possible factors of importance to habitability in environmental enclosures. Diurnal cycles, to which most humans are exposed, influence physiological functions and psychological manifestations to a degree often overlooked. The sitmuli for these cycles may be largely absent in artificial environmental situations, e.g. space ship, and the possible influence of this departure from normal seems a proper matter for study.

The program in physiology for new studies includes several subtasks. One such is a study of the effects of reduced sensory stimulation and its alleviation. An individual enclosed in a space vehicle will suffer reduction in the normal variety and combinations of sensory stimuli and, at the same time, will be subjected to monotonous conditions; for example, long submergence in a submarine under which his neurophysiological functions and efficiency of performance may be modified. It is proposed to study also the effects of reduced energy expenditure on physiological functions and performance. The physical restraints and associated reduction of energy output, due to confinement with limited opportunity for the usual forms of physical exercise, may influence such functions as circulation, metabolism, elimination and may impair the capacity for physical and mental work. A large compression-decompression chamber suitable for use with human subjects will prospectively be available for these studies.

(*b*) *Physiology of diving and submarine escape.*—There are physiologic changes to be expected whenever man is exposed to high partial pressures of the various gas combinations utilized in deep-sea diving. An important part of this program is concerned with problems of acute toxicity due to carbon dioxide and high partial pressures of nitrogen and oxygen. The etiology, prevention, and treatment of diving accidents, such as arterial gas embolism and decompression sickness, are important parts of this program and should provide information that may have wide applicability. At present, using the escape training tank, a well-instrumented recompression chamber, and working with both animals and human beings, the work provides an extension of studies in problems of gas embolism, prolonged exposure to high atmosphere pressures and the overall effects of utilizing artificial atmospheres of elevated ambient pressures. Currently it is planned to extend these problems to include studies covering possible physiologic effects of long-term exposure to unusual partial pressures of various respiratory gas mixtures, artificially constituted. Likewise, man's tolerance to low partial pressures of O_2 has been fairly well defined; but the physiologic problems and limits of chronic exposure to hyperoxic atmospheres are largely undetermined. Studies of prolonged exposures to atmospheres containing partial pressures of O_2 in excess of 160 mm of mercury are within the capabilities of this laboratory, and are planned. This information would be directly applicable to the Navy bioastronautics program. The payloads for outer space capsules should be burdened as little as possible by inert gases man cannot use. If an enriched atmosphere, e.g., 40 percent O_2, can be tolerated for a few hours, this may prove a factor of considerable advantage.

Authority for present and anticipated future programs.—All projects and programs undertaken by this Laboratory are submitted to and approved by the Bureau of Medicine and Surgery and are based on the military requirements as promulgated by the Chief of Naval Operations (Operational Requirements).

Suitability of present and planned facilities for the current and assumed future missions of the Laboratory.—With the imminent installation of the climatized pressure altitude chamber, and the completion of alterations to the Human Factors Engineering Laboratories (in progress), it is considered that adequate facilities will exist for this Laboratory's mission for the foreseeable future.

Roles which the Laboratory could perform in meeting the life sciences research requirements of the Navy if it is not assigned a mission in support of astronautics.—The current research program of this Laboratory is devoted principally to the area of psychophysiological aspects of submarine and diving operations. The program is relative to and could be expanded to an increased range of living and working in restricted or confined environments.

FISCAL DATA

Budget estimates for present (fiscal year 1960) and future (fiscal year 1961) programs in support of aeronautical and space activities. See the fiscal table at the beginning of the Department of the Navy section.

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions, by major categories.—None.

Capital investment in overall plant and equipment, at present and anticipated for future.—(1) Present plant account, $498,546; (2) anticipated fiscal year 1961 plant account, $520,000; (3) percentage relevant to aerospace, 25 percent.

Description and costs of present and future services or project awards to NASA for performance, or performed at in-house facilities for NASA.—For the fiscal year 1960, this activity has proposed trials in connection with the Mercury escape capsule, at an estimated cost of $1,400. Future estimates will depend on tasks assigned to this Laboratory.

Numbers and types of personnel on loan from other Government agencies or on loan to other Government agencies; describe programs involved and reasons for loans.—None.

Major physical resources

Square feet of floorspace:

Office	6,460
Laboratory	43,249
Shop	3,000
Total	52,709

Special laboratory facilities

1. Sound suite: Two anechoic rooms, one large and one small for calibrating instruments and conducting sound experiments; one reverberant room with electronic equipment to produce high intensity noise fields; soundproofed rooms for experiments in psychoacoustics and auditory physiology.
2. Facilities for group audiometry measurements (55-man test capacity).
3. Vision laboratory: Equipped for the study of daylight color sensitivity, night vision acuity, optometry, and colorimetry.
4. Small-group observation laboratory with specialized recording equipment for studies in leadership and group dynamics.
5. Radioisotope suite: For studies in biochemistry and physiology, using tracer techniques.
6. Respiratory laboratory: Equipped with modern instruments for the investigation of various pulmonary functions.

7. Atmosphere laboratory: A capability for physiologic studies of the effects of confinement in artificial atmospheres.

Special apparatus for research

1. Standard Navy recompression chamber located near the submarine escape training tank and modified for special physiologic studies.
2. Temperature and humidity chamber.
3. Climatized pressure altitude chamber with facilities for programing the essential environmental cycles (in process of construction).
4. Equipment for production and study of the effects of high intensity sound.
5. Coblenze galvanometer for measuring radiant energy.
6. Xenon arcs for supplying high intensity radiant energy throughout the light spectrum.
7. Equipment available for field studies: (*a*) Submarine escape training tank (also used for underwater studies); (*b*) conventional and nuclear-powered submarines; (*c*) submarine rescue vessels.

NMRL responsibility and cooperation in Project Mercury

Underwater escape from the Mercury capsule in a simulated water-landing is to be investigated by NMRL personnel in the near future at the request of the Chief of Naval Operations. NMRL has the in-house capability to examine and assess the planned routine for such an escape from under water and stand ready to give such assistance when officially requested. The results of such field tests will apply, it is believed, to other space reentry situations.

Life sciences research in support of aerospace activities

In summary, the large body of data accumulated in NMRL researches relative to living and working in confined environments, as represented by submarines, is immediately available for critical review and evaluation with reference to naval problems and planning in bioastronautics. Habitability research, investigations of respiratory requirements, visual and auditory factors, and personnel assessment, are some of the areas for which NMRL is best suited.

7. U.S. Naval School of Aviation Medicine, U.S. Naval Aviation Medical Center, Pensacola, Fla.

With the declaration of a national emergency by the President of the United States in 1939 the U.S. Naval School of Aviation Medicine was organized and began formal instruction of naval flight surgeons on November 20. As is essential in any training situation, a coordinated program of research in aviation medicine was initiated at the same time. Generally stated, the objectives are to train naval flight surgeons, aviation medical examiners, and aviation medical technicians, and to conduct a broad and effective program of research in aviation and space medicine.

The official statement of the mission is as follows:

The School of Aviation Medicine conducts training and research in aviation medicine.

(1) *Training.*—The training program consists of training medical officers in aviation medicine, qualifying them for the designation of

Naval Flight Surgeon or Naval Aviation Medical Examiner; training enlisted personnel as technical assistants for flight surgeons, qualifying them for the designation of Aviation Medical Technician; providing postgraduate instruction in aviation medicine with particular emphas s on refresher courses for reserve flight surgeons; providing special courses in aviation physiology for medical service corps officers for designation as Aviation Applied Physiologists; assisting in the training of student naval aviators by conducting instruction in, and supervision of, the physiological and aeromedical aspects of high altitude and night flying, and of survival and related equipment. In addition, the school conducts a residency training program for the preparation of applicants for eligibility for certification in aviation medicine by the American Board of Preventive Medicine.

(2) *Research.*—The School of Aviation Medicine conducts basic and applied research in aviation medicine and allied fields. The research laboratories are staffed with scientific personnel and are equipped for conducting research studies in the following program areas: Stress due to acceleration and decleration; stress due to high altitude; stress due to high intensity noise; standards for aviation personnel; aviation safety; escape and rescue; training and reeducation of aviation personnel; psychophysiology including sensations and illusions; and human engineering.

The only change from the original mission has been in degree and complexity of the program required to maintain it. This has been necessitated by such factors as the development of high-performance, high-altitude aircraft and the subsequent increase of physiological and psychological stresses upon the pilot and support personnel; the development of exotic fuels and increased hazards in their handling; the development of new types of aircraft carriers and more complex problems of launch and recovery of the high-performance aircraft; the hazards of high intensity noise from jet engines, and the increased problems of voice communications and operations in this noisy environment.

The major programatic areas are as follows:

(1) The training of medical doctors in the specialty of aviation medicine and their indoctrination in flight training to provide them with an understanding of the many physical and mental problems of the naval aviator and other flying personnel.

(2) The training of selected enlisted personnel as aviation medical technicians as a technical support group for the flight surgeons.

(3) The provision of postgraduate training in aviation medicine and in research in aviation medicine.

(4) The assistance in the training of aviators by instruction in and supervision of the physiological and medical aspects of high altitude and night flying, survival, and related special equipment, such as the antigravity suits which protect against high accelerative forces, etc.

(5) The conduct of basic and applied research on the problem of spatial disorientation by means of special rotation devices which permit the measurement of thresholds of stimulation of the semicircular canals and the otolith organ, and the determination of the human tolerance to simultaneous rotation in more than one plane, as well as to extended rotations for periods of hours and days.

(6) The conduct of basic and applied research on problems of respiration at various altitudes, under various environmental condi-

tions, the improvement of breathing apparatus for both emergency and sealed cabin situations, the detection and control of contaminants or noxious gases, temperature and humidity control.

(7) The conduct of basic and applied research on physical and psychological selection of candidates for aviation training, including physical standards, the prediction of possible future physical disabilities from atherosclerosis, disorders of the nervous system, or disorders of the sensory apparatus; psychological standards and the prediction of success in various stages of training and in operations with the fleet as well as in combat; the psychological methods of improving recruitment and retention in the service, motivation, morale and leadership, as well as improved methods and techniques of training at all levels from indoctrination to training in the fleet.

(8) The conduct of basic and applied research on the biological effects of high intensity noise, voice communications and acoustics on both pilot and support personnel, including problems of communications during operations and combat.

(9) The preparation for and conduct of research on animals projected into ballistic and orbital space flight, including basic studies of the underlying physiological problems as well as the development of protective capsules and equipment to preserve the normal functions of the animals during such flights.

(10) Studies of the biological effects of cosmic and solar radiation by compilation of radiation data, and by evaluation of emulsion packs shot into outer space and recovered, as well as by evaluation of data telemetered back to Earth from extended missile flights through the belts of radiation surrounding the Earth.

(11) The development of bioinstrumentation for the protection of man and animal in missile and orbital shots, and for the measurement and telemetering of physiological data back to Earth both for the purpose of monitoring vital functions and for subsequent analysis of the biological effects of such flights.

(12) The longitudinal studies of aviators to determine the biological effects of life under environmental extremes experienced over a period of 10 years or more.

Planned future major programs are essentially the same as above except that the emphasis has been shifted toward problems of higher altitude, higher speeds of flight, and space flight, during which terrestrially equivalent environment must be provided for the astronauts.

The authority for the present and anticipated future programs depends upon the military requirements as promulgated by the Chief of Naval Operations.

The present buildings, facilities, and equipment available for the present and planned programs are substandard and require modernization. A School of Aviation Medicine Building (approximately $5,500,000) has had planning completed, but is presently listed only in the long-range planning program.

If this establishment is not assigned a mission in astronautics, and if it can be assumed that manned aircraft will continue to be constructed and flown, the requirements for research, development, and training will be met as in the past. The organization, though small, is well rounded in scientific capabilities, and can perform effective basic and applied research in any area of the life sciences.

FISCAL DATA

The budget estimates for present (fiscal year 1960) and future (fiscal year 1961) programs in support of aeronautical and space activities are included in the fiscal table at the beginning of the Department of the Navy section.

Special budget submitted to Bureau of Medicine for submission to NASA.—Fiscal year 1960, $413,500; fiscal year 1961, $113,000.

Grants and contracts.—None.

Estimated replacement cost.—$5,408,000.

Descriptions and costs of present and anticipated future services for NASA

Present programs:

(*a*) Studies of cosmic radiation by evaluation and track count of emulsion packs flown in Mercury capsules in September and December 1959, together with the compilation of radiation data and evaluation in terms of exposure on various ballistic and orbital trajectories. Cost: $2,000.

(*b*) Planning for and direction of the medical aspects of the postflight phases of manned space flight. Cost: $5,200.

Future programs:

(*a*) Continuation of studies of cosmic radiation by monitoring of all Mercury flights, the compilation of all radiation data, together with the development of a composite emulsion pack for combined monitoring with track count and densitometric method for use in cases of unexpected overexposure due to a solar flare or to trajectories through the Van Allen Belt. Cost: $8,000.

(*b*) Continuation of the direction of medical care and supervision of astronauts and animals during preparation for and recovery from all biopacks on a worldwide basis. Cost: $25,000.

Staff breakdown

	Scientific personnel				Administrative and technical support personnel				Tota
	Officers	Enlisted	Civilians	Total	Officers	Enlisted	Civilians	Total	
Bachelor's degree in—									
Chemistry			1	1					1
Physics			2	2					2
Psychology	1		1	2					2
Physiology	1			1					1
Sociology						1		1	1
Library science							1	1	1
French							1	1	1
Business administration							1	1	1
Medical technology							1	1	1
Zoology						1		1	1
Electrical engineering	1			1					1
Master's degree in—									
Psychology	4		2	6					6
Chemistry			1	1					1
Electrical engineering			1	1					1
Doctors of medicine:									
General practitioner	3			3					3
Flight surgeons	[1] 12			[1] 12	1			1	[1] 13
Other doctoral degrees:									
Physiology	1		2	3					3
Psychology	3		4	7					7
Biophysics			1	1					1
Biochemistry			1	1					1
Neurophysiology			1	1					1
Audiology			1	1					1
Optometry	1			1					1
Total	27		18	45	1	2	4	7	52

[1] 7 of these individuals hold boards in one or more of the following: Aviation medicine, neuropsychiatry, ophthalmology, pathology, otolaryngology.

Major physical resources

Laboratory space: 72,000 square feet.

Special laboratory facilities:

(1) Low-pressure chamber (for training).

(2) Basic biochemical laboratory.

(3) Basic physiological laboratory.

(4) Animal experimental irradiation laboratory (15-milliampere 220-kilovolt X-ray unit).

(5) Aviation psychology laboratory, including IBM unit and statistical facilities.

(6) Spectroscopic laboratory (equipped for infrared and invisible light).

(7) Electronmicroscopy laboratory.

(8) Nuclear emulsion laboratory (especially equipped for processing and track evaluation of extremely thick emulsions).

(9) Low-level alpha radiation laboratory (equipped with specially designed low-level alpha counter and pulse ionization chambers).

(10) Medical electronics laboratory.

(11) Electrocardiography laboratory.

(12) Vectorcardiography laboratory.

(13) Ballistocardiography laboratory.

(14) Bioacoustics laboratory (specially equipped for studies in voice communications, high-intensity noise, audiology, and psychoacoustics).

(15) Electrophysiological laboratory (specially equipped for electroencephalography, EEG, airborne EEG, electromyography, EMG, and experimental neurophysiology, neurohistology, and animal surgery).

Special research equipment costing over $25,000 and/or having unique characteristics

(1) Slow rotation room mounted on human centrifuge for studies of prolonged rotation (hours and days), and human and animal tolerance, behavior, and performance under such environmental stress. Related to proposed rotation of space capsules to counteract zero gravity.

(2) Human disorientation device for studies of thresholds of stimulation for the vestibular apparatus and for human tolerance to accelerations in more than one plane. Related to spins, tumbling, and disorientation as may occur during launch, abort, reentry, etc.

(3) Low pressure chamber with sealed environment capsule.

(4) Low pressure chamber with explosive decompression parasite chamber.

8. Aviation Medical Acceleration Laboratory, U.S. Naval Air Development Center, Johnsville, Pa.

The Aviation Medical Acceleration Laboratory was established in June 1952. Its mission is to "perform research and development in aviation medicine." Its tasks are to "conduct research in the general field of aviation and space medicine, aviation physiology, biophysical effects of acceleration forces, and aviation human engineering; develop, improve, test, and evaluate aviation personnel equipment and related aircraft components."

Current major programs

Range of work	Range of outputs
Biological sciences:	
Stress physiology (acceleration stress and disorientation):	
Research, development, test, and evaluation.	Investigate through closed loop dynamic flight simulation effects of low level flight accelerations on pilots, instruments, controls, and restraint gear as related to mission profile of A2F attack aircraft.
Protection and survival of personnel:	
Protection against effects of prolonged and high acceleration stress:	
Research	Explore entirely new and novel methods of protecting animals and human beings from effects of high acceleration stress.
Inflight bioinstrumentation:	
Research, development, test, and evaluation.	Investigate physiological factors to be evaluated in flight; develop sensors and recording apparatus; test and evaluate such equipment for the Navy.
Monitoring evaluation	Provide health physics procedures and monitoring for the Naval Air Development Center.
Closed-space environments (studies of weightlessness (bioprobe)):	
Research	Explore effects of prolonged exposure to weightless state in space, including physiological and performance factors.
Psychological sciences, engineering psychology (effects of acceleration loads on human performance):	
Research, development, test, and evaluation.	Determination of pilot performance in simulated aircraft flight under acceleration. Test and evaluate instruments, controls, and restraint gear as related to aircraft mission.
Research	Determination of effect of vibrations and accelerations on crew performance.
Do	Make theoretical and experimental studies of effects of weightlessness on man.
Aircraft and aircraft support, personnel protection:	
Dynamic flight simulation of aircraft and spacecraft, Mercury program:	
Research, development, test, and evaluation.	Determination of astronaut performance in simulated spacecraft flight under conditions of boost and reentry. Test and evaluate instruments controls and restraint gear as related to spacecraft mission.
Equipment testing:	
Test and evaluation	Evaluate antiblackout valves designed to operate on 70 p.s.i. of oxygen inlet pressure.
Development, test, and evaluation.	Determine thermal protection qualities of aviator's clothing. Explore ways to improve same.
Test and evaluation	Test anti-gravity garments and agree upon common design, materials, color, etc.
Development, test, and evaluation.	Develop improved antiblackout equipment and test and evaluate such equipment for the Navy.
Test and evaluation	Test and evaluate British design anti-gravity suit.
Research, development, test, and evaluation.	Provide adequate protection against damage to the eyes of aircrew during operations. Test and evaluate devices from other sources for the Navy.
Foundational research:	
Research	Study of biochemical factors in stress situations.

Future major programs.—It is considered that the Naval Air Development Center, through its Aviation Medical Acceleration Laboratory, has responsibility for any future program of study concerned with the effects of acceleration on human beings in space flight. A continuation of the current program is envisioned with the following additions:

(1) Study of impact accelerations.
(2) Study of vibration and whole-body oscillations.
(3) The overall direction of the program would be toward increased support of the man-in-space effort, but with the continuation of the aviation medicine program as it exists in development and testing effort.

Authority for present and anticipated future programs.—Military requirements are promulgated by the Chief of Naval Operations and delegated by the Bureau of Naval Weapons and the Bureau of Medicine and Surgery to the Naval Air Development Center.

Suitability of present and planned facilities for the current and assumed future missions of your organization

The current facilities are uniquely suitable for presently assigned bioastronautical work. Planned improvements in facilities planned for orderly shore station development include a current centrifuge modernization program, a new human oscillation device, a new human centrifuge, and a human impact device with collateral laboratory equipments and space. These facilities will increase the capability and suitability of the Aviation Medical Acceleration Laboratory and the Naval Air Development Center for future assumed missions of studies, on a national scale, of acceleration in space.

Other roles the AMAL could perform if not assigned a mission in support of astronautics

The Naval Air Development Center, with its unique combination of laboratories including the Aviation Medical Acceleration Laboratory, provides the most advanced facility in the United States for simulating the acceleration loads of aircraft and spacecraft. Considerable effort of the center is now in support of the national man in space program (NASA) utilizing the capabilities of the eight laboratories of the center. It is anticipated that the development of facilities at the Naval Air Development Center will keep abreast of the demands of the Navy for support in bioastronautics, particularly in all fields related to acceleration.

FISCAL DATA

Budget estimates for present and future programs as well as costs of grants and contracts are treated in the fiscal table at the beginning of the Department of the Navy section.

Capital investment in overall plant and equipment.—Estimated replacement cost, $11,491,000.

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies; describe programs involved and reasons for loans.—Until March 1, 1960, an Air Force veterinary officer was assigned to the Aviation Medical Acceleration Laboratory. A replacement for this officer has been requested and is urgently needed for his capabilities as an animal pathologist, as a project officer in experiments involving animal primates, to supervise the animal colony, and to advise other research personnel on the most efficient choice and utilization of experimental animals.

Major physical resources

Laboratory space:

Staff breakdown

	Scientific personnel				Administrative and technical support personnel				Total
	Officers	Enlisted	Civilians	Total	Officers	Enlisted	Civilians	Total	
Bachelor's degree in—									
Chemistry			1	1					1
Philosophy		1		1					1
Biology	1			1					1
Psychology			2	2					2
Mechanical engineering							1	1	1
Electronics engineer							1	1	1
Mathematics							1	1	1
Journalism							1	1	1
General science							1	1	1
Master's degree in—									
Chemistry			3	3					3
Psychology	1		2	3					3
Physics			2	2					2
Physiology	1		1	2					2
Doctors of Medicine (with specialties below):									
General practitioner	1			1					1
Flight surgeons	3			3					3
Internal medicine	1			1					1
Physiology			1	1					1
Physiology and space medicine			1	1					1
Other doctoral degrees:									
Psychology			2	2					2
Physiology	1		3	4					4
Physics			1	1					1
Biochemistry			1	1					1
Zoology			1	1					1
Total				31				5	36

Special laboratory facilities and items of research equipment

1. Special laboratory facilities:
   (*a*) Physiology laboratory.
   (*b*) Neurophysiology laboratory.
   (*c*) Animal training laboratory.
   (*d*) Human engineering-operator laboratory.
   (*e*) Psychology laboratory.
   (*f*) Biochemistry laboratory.
   (*g*) Biophysics laboratory.
2. Additional special laboratory facilities conveniently available at the Naval Air Development Center, Johnsville, Pa., are:
   (*a*) Aeronautical computer laboratory.
   (*b*) Aeronautical instruments laboratory.
   (*c*) Aeronautical photographic experimental laboratory.
3. Special items of research and development test equipment:
   (*a*) High-altitude chamber.
   (*b*) Human centrifuge. (This is the most advanced human centrifuge known to be in existence today. Its performance capabilities permit simulation of many of the accelerations that will be important in space flight.)
   (*c*) Cinefluorographic apparatus.
   (*d*) Cineradiographic apparatus.

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9. Air Crew Equipment Laboratory, U.S. Naval Air Materiel Center, Philadelphia, Pa.

The ACEL originated as the Aero Medical Department in 1943 as a result of a recommendation by the Bureau of Medicine and Surgery (BUMED). The mission of the ACEL is as follows:

The Air Crew Equipment Laboratory under the administrative and technical control of the Bureau of Naval Weapons and, in matters of aviation medical research, under the technical direction of the Bureau of Medicine and Surgery functions in the following manner to:

(1) Conduct applied engineering research, design, development, test, and operational evaluation of naval aircrewmen and space crewmen personal and safety equipment previously established as a requirement by the Chief, Bureau of Naval Weapons. The engineering developments shall be in concert with known or experimentally defined biological, psychological, and human engineering concepts to insure total bioengineering integrity of the equipments. The laboratory shall also recommend rules and policies concerning health hazards incident to the use of these equipments in air operations for further promulgation by the Bureau of Naval Weapons;

(2) Conduct basic and applied research in the biological, psychological, and human engineering aspects of aviation medicine as it pertains to the personal and safety equipment of naval aircrewmen and space crewmen and to their ability to perform satisfactorily under all of the stresses of their environment; and

(3) Engage in engineering and biological research and development in the fields of aircraft nuclear propulsion and space and orbital flight in anticipation of future aircrew or space crew equipment requirements as projected trends in naval aviation and astronautics become apparent.

The principal change of the present mission over the original mission is the inclusion to cover research and development for nuclear propelled aircraft and space and orbital flight.

Current major programs

(1) Full pressure and space suits.
(2) Oxygen breathing systems.
(3) Protective clothing.
(4) Emergency escape, restraint, and crash safety systems.
(5) Survival and rescue systems.
(6) Human factors in cockpit design.
(7) Environmental aspects of space flight.
(8) Basic research.

Future major programs

The programs above will be continued. However, it is planned to increase the emphasis on space and orbital flight with particular emphasis on the following areas:

(1) Radiation: (*a*) Nuclear, (*b*) ground-support aspects.
(2) Environment: (*a*) Toxic, (*b*) noise, (*c*) physical, (*d*) physiological, (*e*) psychological, (*f*) visual, (*g*) temperature.
(3) Acceleration: (*a*) Linear, (*b*) vibration, (*c*) impact.
(4) Training of astronauts: (*a*) Flight simulation.

(5) Monitoring of spacecraft.
(6) Survival: (*a*) Aloft, (*b*) ejection (escape), (*c*) recovery.
(7) Performance (as a whole).
(8) Biosupport (pre- and post-flight).
(9) Life support systems: (*a*) Oxygen recovery and regeneration systems, (*b*) reclaiming waste products.
(10) Fundamental biology.
(11) Bioinstrumentation and data handling.
(12) Operations research.

Authority for present and anticipated future programs.—Military requirements as promulgated by Chief of Naval Operations.

Suitability of present and planned facilities for current and assumed future mission of the ACEL.—The basic facilities presently available and planned for are considered to be adequate to support the research and development for conventional, manned types of aircraft and an extensive space and orbital flight program. An expanded or accelerated program for a space effort will necessitate some modifications to extend the range and increase the dynamic control of the bioastronautics test facility, the altitude/thermal/explosive decompression facility, and the new high-altitude or space chamber.

If the space program is to be expanded and more laboratory space is required, it can be made available by modifications and rehabilitation of existing buildings at the Naval Air Materiel Center.

If not assigned a mission in support of astronautics, other roles which ACEL could perform in meeting the life sciences research requirements of the Navy.

The ACEL has the staff and equipment to undertake a wide variety of supporting studies and equipment developments which will be needed to adapt man to his weapons systems and to assure his military effectiveness, safety, and comfort.

Personnel on loan to or from other Government agencies.—None.

FISCAL DATA

Budget estimates for present and future programs as well as costs of grants and contracts are treated in the fiscal table at the beginning of the Department of Navy section.

Capital investment in overall plant and equipment.—Estimated replacement cost, $5,616,000.

Major physical resources

(*a*) Square feet of floorspace: 129,496 square feet, including offices, laboratories, and test areas.
(*b*) Special laboratory and other facilities:
(1) The altitude/thermal/decompression facility at the ACEL is believed to be the only facility in the country capable of simulating the complete thermal profile of space flight, including prelaunch, launch, orbit, reentry, and postlanding conditions.
(2) Body temperature laboratory.
(3) Physiology and chemistry laboratory.
(4) Respiration laboratory.
(5) Electronic shop and laboratory.
(6) Human engineering laboratory.

(7) Low-pressure laboratory.
(8) Environment laboratory.
(9) Liquid oxygen laboratory.
(10) Model shop.
(11) Sewing room.
(12) Adhesives laboratory.
(13) Physiological acoustics laboratory.
(14) Electrophysiology laboratory.

(*o*) Special research equipment:
(1) Ejection seat test tower.
(2) Static seat ejection recovery net.
(3) Linear accelerator.
(4) Vertical "bounce" tower.
(5) 30 by 30-foot underwater ejection tank.
(6) Ejection seat environment simulator.

Staff breakdown

	Scientific personnel				Administrative and technical support personnel				Total
	Officers	Enlisted	Civilians	Total	Officers	Enlisted	Civilians	Total	
Bachelors degree in—									
Chemistry			4						4
Biology			3						3
Psychology	1		1						2
Mechanical engineering			7				2		9
Physics			6						6
Industrial engineering			1				1		2
Chemical engineering			1						1
Business administration							1		1
Masters degree in—									
Chemistry									0
Biology			2						2
Psychology	1		1						2
Other (specify)									0
Doctors of medicine:									
General practitioner	1								1
Flight surgeons	1				1				2
Other specialties (specify)									0
Other doctoral degrees:									
Biochemistry					1				1
Physiology			1						1
Psychology			2						2
All others (without degree):									
Professionals			6						6
Subprofessional (including work-study students)						17	17		34
Clerical						2	10		12
Shop personnel							28		28
Total	4		35		2	19	59		119

DEPARTMENT OF THE ARMY

A. Department of the Army Fiscal Summary for Aerospace Related Life Programs

Installations	Research budget	
	Fiscal year 1960	Fiscal year 1961
Walter Reed Army Institute of Research	$1,409,000	$1,270,000
U.S. Army Medical Research Laboratory	372,000	343,000
U.S. Army Medical Research and Nutrition Laboratory	309,000	200,000
QM Research and Engineering Center Laboratory	805,600	830,000
QM Food and Container Institute	235,200	95,000
U.S. Army Biological Warfare Laboratories	30,000	1,370,000
Human Resources Research Office	100,000	110,000
Personnel Research Branch, The Adjutant General's Office	165,000	195,000
Total	3,425,800	4,413,000

B. Department of the Army Staffing Summary for Aerospace Related Life Science Programs

Installations	Doctors [1]		Masters		Bachelors		Supporting [2] staff		Total
	Military	Civilian	Military	Civilian	Military	Civilian	Military	Civilian	
Walter Reed Army Institute of Research [3]	4	1							5
U.S. Army Medical Research Laboratory [3]	2	4	1						7
U.S. Army Medical Research Nutrition Laboratory [3]	3	1							4
Q.M. Research and Engineering Center Laboratory	1	63		53	7	208		415	747
Q.M. Food and Container Institute		18		36	1	69		16	140
U.S. Army Biological Warfare Laboratories	3				9	5			17
Human Resources Research Office		3				1		2	6
Personnel Research Branch, The Adjutant General's Office		3	2	6	3	1		5	20
Total	13	93	3	95	20	284		438	946

[1] Includes M.D., Ph. D., dentists, veterinarians.
[2] Includes technicians, stenographers, and other support personnel.
[3] Figures refer only to that part of staff involved in research most relevant to aerospace activities.

C. Life Science Programs

1. Walter Reed Army Institute of Research, Washington, D.C.
2. U.S. Army Medical Research Laboratory, Fort Knox, Ky.
3. U.S. Army Medical Research and Nutrition Laboratory, Fitzsimons Army General Hospital, Denver, Colo.
4. Quartermaster Research and Engineering Center Laboratories, Quartermaster Research and Engineering Command.

5. Quartermaster Food and Container Institute for the Armed Forces, Quartermaster Research and Engineering Command.
6. U.S. Army Biological Warfare Laboratories, Fort Detrick, Md.
7. Human Resources Research Office, Washington, D.C.
8. Personnel Research Branch, The Adjutant General's Office.

1. WALTER REED ARMY INSTITUTE OF RESEARCH, WASHINGTON, D.C.

The Walter Reed Army Institute of Research was first established in 1893 as the Army Medical School at the instigation of Surg. Gen. George M. Sternberg. The school was redesignated the Medical Department Professional Service Schools in 1923 when it became a component of the Army Medical Center. Throughout World War II, the school conducted an expanded education program for Medical Corps Officers. In 1955, the name was changed to its present official title, Walter Reed Army Institute of Research.

Mission

(1) Conduct research and evaluation studies in the military aspects of the biological and medical sciences, correlate these findings with data from other sources, and disseminate the basic tenets derived therefrom in a graduate educational program as required for the national defense.

(2) Plan and conduct the Army Medical Service's medical, dental, veterinary, and allied sciences advanced technical and graduate educational programs required for the military aspects of professional practice in support of the Army's mission in national defense.

(3) Plan and conduct research and development in relation to this program on approved projects of the Chief of Research and Development, Department of the Army, as assigned by the U.S. Army Medical Research and Development Command, Office of the Surgeon General, and to correlate those research activities within its sphere that are conducted by other Medical Service laboratories.

(4) Provide advisory services on problems in procedure or technique in military medicine, dentistry, and veterinary medicine; provide special technical quality control where required; and conduct development studies in relation to biologic products presenting problems of military importance.

(5) Act as a diagnostic reference source for installations of the Army for difficult Medical Service problems and evaluations that require complicated analyses or tests not available in other Army installations.

(6) Provide technical supervision for research conducted by—
Army Medical Research Unit, Kuala Lumpur, Malaya.
Army Medical Research Unit, Europe, Landstuhl, Germany.
Army Medical Research Unit, Panama.

Current major programs.—None in direct support of aeronautical and space activities. The following tasks are of potential interest to aeronautical and space activities:

(1) Chemical protection against total body radiation. This task is to develop an antiradiation drug which can be taken before exposure, to reduce the biological effects of ionizing radiation.

(2) Psychological and physiological reactions to stress. This task is to determine the widespread effects of stresses on the physiological functioning of the soldier and to search for constructive means to modify the adverse effects and to prepare him for most effective performance. Primate performance under space conditions was studied under this task during 1959 in Jupiter AM–18 bioflight 2, with studies of primates Able and Baker in cooperation with the U.S. Navy and with partial funding by the National Aeronautics and Space Administration.

Future major programs.—None are planned for direct support of aeronautical and space activities.

Authority for present and anticipated future programs.—Not applicable.

Suitability of present and planned facilities to the current and assumed future missions of the organization.—Not applicable.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services? Current research programs are in support of the mission of the Army Medical Service. These studies will be continued.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–61)

	Fiscal year 1960	Fiscal year 1961
1. Chemical protection against total body radiation	$262,000	$175,000
2. Psychological and physiological reactions to stress	215,000	200,000
Total	477,000	375,000

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories.—All contracts and grants are made by the U.S. Army Medical Research and Development Command, Office of The Surgeon General, Department of the Army. The following are in support of the tasks above:

	Fiscal year 1960	Fiscal year 1961
1. Chemical protection against total body radiation	$862,000	$825,000
2. Psychological and physiological reactions to stress	70,000	70,000
Total	932,000	895,000

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies.—Not applicable.

Staff breakdown[1]

	Scientific staff		
	Military	Civilian	Total
Ph. D.: Research psychologist	2	0	2
MD: Nuclear medicine	1	1	2
Veterinary toxicologists	1	0	1

[1] Refer to that part of staff involved in above-listed projects.

Numbers and types of personnel or loan to other Government agencies or on loan from other Government agencies.—

(1) One medical officer, aviation medicine, loaned to NASA Space Task Group, Langley Field, Va., in support of Project Mercury.

(2) One Medical Service Corps officer, research psychologist, loaned to the USAF, Holloman AFB, for operant conditioning of primate colony, Project Mercury, funded by NASA.

(3) One Medical Service Corps officer, research psychologist, consultant to USAF, Holloman AFB, for operant conditioning of primate colony, Project Mercury, funded by NASA.

(4) One Medical Service Corps officer, administrative officer, loaned to Armed Forces–National Research Council Committee on Bioastronautics, for advisory services.

Major physical resources.—No specific facilities or equipment are devoted to bioastronautics.

2. U.S. Army Medical Research Laboratory, Fort Knox, Ky.

The U.S. Army Medical Research Laboratory was established September 1, 1942, through the combined efforts of the Surgeon General, U.S. Army; the Surgeon of the Armored Force; and the Committee on Industrial Hygiene of the National Research Council, to study the physical and mental stresses placed upon the soldier in the operation of armored vehicles. It was designated the Army Ground Forces Armored Research Laboratory. As its scope of activity and its mission changed, it was known at various times by the following official names: Armored Medical Research Laboratory, Medical Department Field Research Laboratory, Army Medical Research Laboratory, and U.S. Army Medical Research Laboratory. On October 3, 1958, the Laboratory was assigned to the U.S. Army Medical Research and Development Command.

The current mission of the Laboratory is to conduct basic and applied research on physiological, biochemical, biophysical and psychological problems that have military significance. This includes research on physiological and psycho-physiological responses to various environmental factors such as heat, cold, radiation, noise, vibration, blast and all other macroenvironmental and microenvironmental factors which affect the soldier's operating efficiency or ability to survive; the basic biological aspects of ionizing and nonionizing radiation; research directed toward improvement of field X-ray techniques used by the Army Medical Service; field research; and studies on human engineering problems arising from expanded global military operations.

Current major programs.—Although there are no programs in aeronautics or space activities, the following tasks are considered of potential interest:

(1) Vision and perception in relation to performance. This task is designed to gain knowledge regarding the adaptation of known human perceptual abilities to the requirements of military weapons and other man-machine systems.

(2) Audition and sound in relation to performance. This task is to determine the limits and variations in psychological and physiological capabilities under a variety of noise environments.

(3) Physiology of the effects of cold. This task is to study the basic physiological mechanisms involved in cold adaptation, to contribute to the solution of problems concerned with employment of military forces in a cold environment.

Future major programs.—None planned for support of aeronautical or space activities.

Authority for present and anticipated future programs.—Not applicable.

Suitability of present and planned facilities to the current and assumed future missions of the organization.—Not applicable.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services?—The research program supports the mission of the Army Medical Service. Current research orientation will continue.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–61)

	Fiscal year 1960	Fiscal year 1961
1. Vision and perception in relation to performance	$37,000	$40,000
2. Audition and sound in relation to performance	37,000	40,000
3. Physiology of the effects of cold	134,000	95,000
Total	208,000	175,000

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories.—All contracts and grants are made by the U.S. Army Medical Research and Development Command, Office of the Surgeon General, Department of the Army. The following are in support of the tasks above:

Grant and contracts

	Fiscal year 1960	Fiscal year 1961
1. Vision and perception in relation to performance	$23,000	$23,000
2. Audition and sound in relation to performance	55,000	55,000
3. Physiology of the effects of cold	86,000	90,000
Total	164,000	168,000

Capital investment in overall plants and equipment, both at present and anticipated for future.—Not applicable.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies.—Not applicable.

Staff breakdown[1]

	Scientific staff		
	Military	Civilian	Total
Doctor of philosophy, research psychologist	2	4	6
Master's degree, optometrist	1	0	1

[1] Refers to that part of staff involved in above-listed projects.

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies. None.

Major physical resources. No specific facilities or equipment are devoted to aeronautics or space activities.

3. U.S. Army Medical Research and Nutrition Laboratory, Fitzsimons Army General Hospital, Denver, Colo.

The Laboratory, as presently constituted, was established through a consolidation of two previously existing laboratories—the U.S. Army Medical Nutrition Laboratory, and the U.S. Army Research and Development Unit. The history of the present unit, therefore, consists of two parts—one pertaining to the Nutrition Laboratory and the other to the R. & D. unit.

(1) *Nutrition.*—The Laboratory had its beginning during World War I in the Division of Food and Nutrition of the Medical Department. In the years intervening between World War I and World War II, nutrition studies in the Army were greatly curtailed. They were continued at the beginning of World War II in the Nutrition Laboratory at the Army Medical Center, Walter Reed Army Hospital. In September 1944, the Nutrition Laboratory at the Army Medical Center was transferred to the Quartermaster Depot, Chicago, and designated as the Medical Nutrition Laboratory. In September 1953, the Laboratory was moved to Fitzsimons Army Hospital, Denver. In January 1957, it was redesignated the U.S. Army Medical Nutrition Laboratory. Effective September 1, 1958, the Laboratory was consolidated with the U.S. Army Research and Development Unit at Fitzsimons, and designated the U.S. Army Medical Research and Nutrition Laboratory.

(2) *Research and Development unit.*—The unit was first established at Fitzsimons Army Hospital as a branch of the hospital under the title of the Research and Development Branch on October 1, 1947; subsequently reorganized in January 1955 as the Research and Development Unit, Fitzsimons Army Hospital. It was subsequently redesignated as the U.S. Army Research and Development Unit. The consolidation with the U.S. Army Medical Nutrition Laboratory was effected on September 1, 1958.

Mission

(1) To investigate the adequacy of the soldier's diet and determine the nutrition intake; assess the health as related to nutritional status of troops in all environments, recommend nutritional measures de-

signed to insure that the troops are as healthy and fit as is compatible with local danger, disease, and environment; devise and recommend nutritional means to prevent disease and damage to troops under all conditions; and observe and make recommendations on the nutrition and nutritional status of civil populations under military control.

(2) To investigate clinical problems in the field of internal medicine and therapeutics. Special attention is given to pulmonary diseases, and cardiovascular surgery.

Current major programs.—There are no programs in support of aeronautics and space activities. The following tasks are of potential interest:

(1) Minimal nutritional requirements. This task is to determine the lowest level of nutrients at which the soldier can function effectively under varying environmental circumstances.

(2) Studies on algae as a food source. This task is designed to determine the value of algae as a caloric and protein source.

Future major programs.—There are no plans for a future program in aeronautics and space activities.

Authority for present and anticipated future programs.—Not applicable.

Suitability of present and planned facilities to the current and assumed future missions of this organization.—Not applicable.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services?—The research program of the U.S. Army Medical Research and Nutrition Laboratory was established to support the mission of the Army Medical Service. Studies will continue as currently oriented.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–61)

	Fiscal year 1960	Fiscal year 1961
1. Minimal nutritional requirements	$250,000	$180,000
2. Studies on algae as a food source	20,000	20,000
Total	270,000	200,000

Costs of present and anticipated future services or project awards to nongovernmental groups or educational institutions by major categories.—All contracts and grants are made by the U.S. Army Medical Research and Development Command, Office of The Surgeon General, Department of the Army. The following are in support of the tasks above:

Grants and contracts

	Fiscal year 1960	Fiscal year 1961
1. Minimal nutritional requirements	$30,000	0
2. Studies on algae as a food source	0	0
Total	30,000	0

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at inhouse facilities for other Government agencies.—Not applicable.

Staff breakdown[1]

	Scientific staff		
	Military	Civilian	Total
Doctor of Philosophy:			
Biochemist	1	1	2
Microbiologist	1		1
Doctor of medicine: Internist	1		1

[1] Refers to that part of staff involved in above-listed projects.

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies.—None.

Major physical resources.—No specific facilities or equipment are devoted to bioastronautics.

4. Quartermaster Research and Engineering Center Laboratories, Quartermaster Research and Engineering Command

In 1935 a Research and Development Branch was established in the Office of the Quartermaster General. The Quartermaster research and development laboratories were located at Jeffersonville, Ind.; Philadelphia, Pa.; Lawrence, Mass.; Cameron, Va.; and Chicago, Ill. The Headquarters, Quartermaster Research and Development Command, was established at Natick, Mass., on October 1, 1953. The scientific activities were officially separated as a subordinate element, the Quartermaster research and engineering center laboratories, on May 28, 1957.

The mission is to execute a research and/or development program concerned with basic research on the operational capability of the Quartermaster Corps equipped soldier under varying degrees of natural and military environmental stresses.

Current major programs.—None of the current major programs are directly in support of aeronautical and space activities. The following tasks may contribute relevant information:

(1) Thermal protection of the individual soldier—Tasks:
- Investigation of the heat flow.
- Investigation of the thermal characteristics of halogenated compounds.
- Study of means of dissipating intense thermal energy in materials using photosensitive dyestuffs.
- Investigation of materials for protection of the eyes against the flash effects of nuclear detonations.

(2) Combat and special-purpose clothing and equipment—Task: Application of heating and cooling systems to clothing.

(3) Quartermaster pioneering research—Tasks:
- Study of the spectral qualities polarization, and light pressure properties of solar radiation.

Basic research on the biological and biochemical reactions of microorganisms.
Synthesis and/or isolation of organic compounds in food.
Isolation and synthesis of radiation protective chemicals in food.
Isolation and synthesis of volatile compounds and their precursors in vegetables.
Basic research in radiation chemistry, physics, and biology.

Future major programs.—None planned.

Authority for present and anticipated future programs.—Not applicable.

Suitability of present and planned facilities to the current and assumed future missions of this organization.—The present and planned facilities are directed to and are adequate for the acomplishment of the mission.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services?—Research on basic and life sciences will continue with appropriate coordination with other elements of the armed services.

FISCAL DATA

Budget estimates for present and future programs and costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories

Task	Total budget		Contractor	Contracts	
	1960	1961		1960	1961
Heat flow principle	$33,000	$34,000			
Halogenated compounds	50,000	50,000	Pennsalt Co	$25,000	$25,000
Dissipation of thermal energy	5,000	0	American Cyanamid	[1] 10,000	
Flash protection	70,000	70,000	Polo Coat Co	30,000	30,000
			Mine Safety	19,000	10,000
			Mark Polarized Co	0	18,000
Integrated clothing	166,000	206,000			
Thermalibrium and auxiliary heating	189,000	225,000	Westinghouse	99,600	43,000
			Harris Research	12,000	18,000
			Undetermined	10,000	0
			do	0	16,500
Polarization and light pressure	1,000	3,500			
Secretion of enzymes by fungi	18,000	21,000			
Radiation protective chemicals in food	10,000	8,000			
Volatile compounds in food	10,000	12,000			
Radiation chemistry, physics, and biology	34,000	40,000			
Total	591,000	669,500	Total	214,600	160,500

[1] From 1959 funds which expire in June 1960.

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable. The research related to astronautical and space activities is a minor part of the total program.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies.—None.

Major physical resources

Square feet of floor space.—Not applicable as this is an integrated part of the overall organizational facility.

Special laboratory facilities.—Not applicable.

Special items of research equipment ($25,000 or more per item).—The only major resource of direct significance for aeronautics and space activities is the solar furnace. This facility costs $277,000 and provides a flux up to 100 gram-calories per square centimeter per second over a disk of 10 centimeters in diameter.

Staff breakdown

	Scientific staff			Administrative and technical support staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Ph. D.:							
Biology		1	1				1
Microbiology		2	2				2
Physiology	1	6	7				7
Entomology		4	4				4
Anthropology		1	1				1
Meteorology		1	1				1
Mycology		1	1				1
Food technology		1	1				1
Geography		6	6				6
Physics		5	5				5
Analytical chemistry		3	3				3
Biochemistry		4	4				4
Organic chemistry		15	15				15
Physical chemistry		5	5				5
Psychology		6	6				6
Mechanical engineering		1	1				1
Economics		1	1				1
Master's degrees		53	53				53
Bachelor's degrees	6	195	201	1	13	14	215
All other personnel, scientific staff		106	106		309	309	415

N.B.: The above figures represent the total R. & D. and support personnel of the laboratories. Of these, it is estimated that about 18 man-years of scientific and 17 man-years of technical support effort are devoted annually to the listed activities.

5. Quartermaster Food and Container Institute for the Armed Forces, Quartermaster Research and Engineering Command

In 1936 a Subsistence Research Laboratory was established at the Chicago Quartermaster Depot. In 1942 the name of the Laboratory was changed to the Quartermaster Subsistence Research and Development Laboratory. Throughout the years, the mission was expanded to include research and development responsibility for containers and packaging and packing materials, as well as Department of Defense R. & D. responsibility for food. The Laboratory was redesignated the "Quartermaster Food and Container Institute for the Armed Forces" in March 1946, and designated an activity of the Quartermaster Research and Engineering Command on October 1, 1953.

Mission.—The mission is to execute a research and/or development program concerned with basic research in food nutrition, stability, and acceptance; design, development, evaluation of military rations and food products for the Armed Forces; development and evaluation of containers; research on irradiation preservation processes.

Current major programs.—The Institute has no program directly in support of aeronautic and space activities. The following contribute relevant information:

(1) Food products development—Tasks: Development of foods for high altitude feeding.

(2) Food research—Tasks: The relationship of nutrition to performance of stressful workloads as a basis for establishing minimal

ration requirements. The feasibility of microbiological methods of producing food.

Future major programs.—A program on the food and water aspects of man's space exploration has been forwarded to NASA for consideration.

Authority for present and anticipated future programs.—Not applicable.

Suitability of present and planned facilities to the current and assumed future missions of this organization.—The present and planned facilities are adequate for the accomplishment of the mission.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services? Research will continue as presently oriented.

FISCAL DATA

Budget estimates for present and future programs.—

(1) See fiscal data table.

(2) Proposed program on the food and water aspects of man's space exploration: $3,340,000.

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories.—See fiscal data table.

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable as research related to astronautical and space activities is a minor part of the program.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies.—See fiscal data table.

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies; describe programs involved and reasons for loans.—None.

Major physical resources

Square feet of floorspace.—Not applicable as this is an integrated part of the overall organizational facility.

Special laboratory facilities.—Not applicable.

Special items of research equipment.—None.

FISCAL DATA

Task	Total Budget		Contracts			Transfer from U.S. Air Force to Quartermaster	
	1960	1961	Contractor	1960	1961	1960	1961
Food for high-altitude feeding.			American Can	$2,000		$67,700	$60,000
			Sun Tube Corp	3,000			
			Undetermined	22,500	(1)		
Nutrition and stressful workloads.	$60,000	$35,000	Northwestern University	20,000			
			Lankenau Hospital	40,000			
Microbiological methods for producing food.	20,000						
Total	80,000	35,000	Total	87,500		67,700	60,000

[1] Air Force plans not known at this time.

Staff breakdown

	Scientific staff			Administrative and technical support staff			Total
	Military	Civilian	Total	Military	Civilian	Total	
Ph. D.:							
Microbiology		2	2				2
Physiology		2	2				2
Plant physiology		1	1				1
Food technology		3	3				3
Nutrition		1	1				1
Organic chemistry		1	1				1
Agricultural biochemistry		2	2				2
Psychology		1	1				1
Dairy science		3	3				3
Natural science		1	1				1
American literature		1	1				1
Master's degrees: Scientific		36	36				36
Bachelor's degrees		69	69	1		1	70
All other personnel: Scientific staff		16	16			92	108

NOTE.—An estimated 13 man-years of scientific, and 10 man-years of technical support effort per year for above-listed projects. Only military personnel with a direct responsibility in a scientific program are shown.

6. U.S. ARMY BIOLOGICAL WARFARE LABORATORIES, FORT DETRICK, MD.

Mission.—To conduct a research and development program in offensive and defensive biological warfare. The program includes biological agents, weapons, and protective measures.

Current major programs.—No major program. Related task as follows: Decontamination measures for protection against BW research and development hazards. Object, to develop disinfectants and procedures for the sterilization of biological agents. NASA has requested the Chemical Corps to perform a study of adequate means for sterilization of space probes.

Future major programs.—None. The Chemical Corps has proposed a program to NASA on the food and water aspects of man's space exploration.

Authority for present and anticipated future programs.—Not applicable.

Suitability of present and planned facilities to the current and assumed future missions of this organization.—The Laboratories' facilities are suitable for conducting the mission outlined above.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life science research requirements of the armed services?—The Chemical Corps would continue work on its mission and the NASA task it is now conducting. The program listed above will be started provided NASA approves and cites the necessary funds.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960 and 1961).—(1) Present, $30,000; (2) proposed program on the food and water aspects of man's space exploration, $1,370,000.

Costs of present and anticipated future services or project awards to nongovernmental groups or educational institutions by major categories.—None.

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable (amount insignificant).

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at inhouse facilities for other Government agencies.—None.

The chart below gives personnel in the Protective Branch, Physical Defense Division:

	Scientific staff		
	Military	Civilian	Total
Doctor of philosophy: Chemistry	1		1
Doctor of medicine:			
Chemistry	1		1
Bacteriology	1		1
Bachelor of science:			
Chemistry	3	5	8
Engineering	2		2
Biology	3		3
Medical technician	1		1
Total	12	5	17

There are a total of 11 technicians and administrative personnel supporting the scientists.

Major physical resources.—None.

7. Human Resources Research Office, Washington, D.C.

The Human Resources Research Office (Humrro), George Washington University, is an Army contract agency, established in 1951, which conducts a research program in personnel management, training methods, motivation, morale, and leadership.

Current major program.—Humrro has no program in bioastronautics. One of its units, located at Presidio, Monterey, Calif., conducts a task to determine the role of isolation effects in complex learning and motivation and the performance of individuals under conditions of prolonged minimization of sensory input.

Future major programs.—None is planned. The study method above will continue.

Authority for present and anticipated future programs.—Army Regulations 70–8, Human Factors Research, which establishes the Humrro mission as stated above.

Suitability of present and planned facilities to the current and future missions of this organization.—Facilities are in keeping with the Army mission.

If not assigned a mission in support of astronautics, what other roles could this organization perfor min meeting life sciences research requirements of the armed services?—Humrro will continue research to solve Army problems in training.

FISCAL DATA

Budget estimates for present and future programs fiscal year 1960–61.—Fiscal year 1960, $100,000; fiscal year 1961, $110,000.

Costs of present and anticipated grants and contracts to nongovernmental groups or educational institutions by major categories.—The task is part of a larger contract to an educational institution.

Capital investment in overall plant and equipment, both at present and anticipated for future.—Instrumented isolation chambers developed over the past 3 years at a cost of $87,000. These facilities are property of the Army.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at inhouse facilities for other Government agencies.—Not applicable.

Staff breakdown.—Doctor of philosophy, psychology, 3; bachelor's, physics, 1; administrative support, 2.

8. Personnel Research Branch, The Adjutant General's Office

Name, origin, and mission.—The Personnel Research Branch, The Adjutant General's Office conducts research in personnel operations, selection, classification, assignment, and utilization for the Army in accordance with Army Regulation 70–8, Human Factors Research.

Current major programs.—No task in this program is directed toward bioastronautics. Two tasks may produce information of value. These tasks are:

(1) Image interpretation: The determination of the common and unique psychological abilities, skills, and techniques involved in image interpretation via the several media, and

(2) Errorfree performance: A study of human performance on jobs where a principal requirement is the capacity to pay close and sustained attention to details of a particular assignment.

Future major programs.—No bioastronautic study is planned. The studies discussed above will be continued.

Authority for present and anticipated future programs.—Army Regulation 70–8 which establishes the Personnel Research Branch mission as stated above.

Suitability of present and planned facilities to the current and future missions of this organization.—Facilities are in keeping with the Army mission assigned to Personnel Research Branch.

If not assigned a mission in support of astronautics, what other roles could this organization perform in meeting life sciences research requirements of the armed services?—Personnel Research Branch will continue research to solve Army problems in assigned area of responsibility.

FISCAL DATA

Budget estimates for present and future programs (fiscal year 1960–61).—The tasks discussed above are funded at $90,000 and $75,000, respectively in 1960. The tasks will be funded at $120,000 and $75,000 in fiscal year 1961.

Costs of present and anticipated grants and contracts to non-governmental groups or educational institutions by major categories.—None.

Capital investment in overall plant and equipment, both at present and anticipated for future.—Not applicable.

Descriptions and costs of present and anticipated future services or project awards to other Government agencies for performance, or performed at in-house facilities for other Government agencies.—None.

Staff breakdown

	Scientific		Administrative	
	Military	Civilian	Military	Civilian
1. Errorfree performance:				
Ph. D., in psychology		2		
MA in psychology		3		
Masters, electrical engineers	2			
Administrative assistants				2
Total	2	5		2
2. Imagery:				
Ph. D. in psychology		1		
Masters in psychology		3		
Bachelor:				
Geographer	1			
Political scientists	1	1		
Photo interpreter	1			
Administrative assistants				3
Total	3	5		3

Numbers and types of personnel on loan to other Government agencies or on loan from other Government agencies.—None.

Major physical resources

Square feet of floorspace.—Not applicable as the space used is integral to the facility which supports many other research tasks.

Special laboratory facilities.—None.

Special items of research equipment ($25,000 or more per item).—None.

PART IV. COORDINATION AND UTILIZATION OF PROGRAMS, RESOURCES, AND FACILITIES

In an address, "Future Research in Aerospace Medicine," on January 15, 1960, Col. John E. Pickering, Director of Medical Research in the USAF School of Aviation Medicine of the Aerospace Medical Center, Brooks Air Force Base, Tex., made the following statement:

> * * * we have seen over the past 2 years a tremendous growth in our national biomedical space effort. Nearly every institution and industrial organization has some facet of a space medicine research effort. Additionally, practically everyone in this audience has a personal interest in space research or is a member of one or more space committees. Yet with all of this, we are still without a central coordinated space biology research team. Programs are being pursued on a near individual basis without benefit, in many instances, of advice and experience of interested and knowledgeable people. As a consequence we are in fact diluting our national talent to such an extent that the future may not hold much more hope for real success and understanding than the past, and a record of the past is not necessarily one of sound and rigorous scientific achievement * * *.

This expressed need for coordination in space medicine programs may well serve as a timely example in considering the adequacy of present and proposed structures and mechanisms for coordination of space-related life science programs.

1. Present and Proposed Coordination of Life Science Programs

During the 2d session of the 86th Congress, hearings were held by both the House Committee on Science and Astronautics (title of printed hearing: "To Amend the National Aeronautics and Space Act of 1958") and the Senate Committee on Aeronautical and Space Sciences (title of printed hearing: "NASA Authorization for Fiscal Year 1961—Part I") which included consideration of some of the problems involved in coordination of the various life science programs of the Federal Government. Following are excerpts from testimony on the subject with page references to the hearings from which they were taken.

[Excerpts from House hearing]

A. Testimony of Dr. T. Keith Glennan, Administrator, National Aeronautics and Space Administration, and Dr. Hugh L. Dryden, Deputy Administrator

Mr. Daddario. Dr. Glennan, on March 1 you announced the appointment of Dr. Clark Randt as the Director of the Office of Life Sciences.

Dr. GLENNAN. Yes, sir.

Mr. DADDARIO. At the same time you stated the two objectives of space research, to provide for research, development and training, in the scientific and technological aspects of manned space flight and to investigate fundamental biological problems relative to space environments including research for extraterrestrial life.

Now, where will these facilities be built?

Dr. GLENNAN. Presently, we have discussed building a small research establishment, either on the grounds of Goddard Space Flight Center or perhaps at the National Institutes of Health. There are reasons for considering one as against the other. For instance, the close association between the physical scientists, worrying about space flight, and satellite flights, that sort of thing, with the life scientists, is to be desired. On the other hand, there is to be considered the community of interest of the people working in our life sciences program, particularly in the bioscience area, with their colleagues in life sciences in other fields.

Actually, Mr. Daddario, we do not plan to build such an establishment immediately.

Our initial activities in that field will be the development of a program of research in which we will support activities—research activities—on college campuses, medical schools, and in the laboratories of the military services, particularly in the latter case in those areas where bioastronautics is involved.

Mr. DADDARIO. * * *

Now, we have air medical research centers at Wright Field, and Brooks Air Force Base, Holloman, Johnsonville, and through the testimony that has been given to the committee, it appears that we already have facilities for just the things you are talking about now. Are they going to be used? How will they be used? Will you give your requirements to them? Will their facilities that have been developed and the training that they have had over the course of time be properly utilized? Is it necessary even to have a small medical center of your own? Cannot these people, who have already spent millions of dollars, be used for this particular purpose? Brooks Air Force Base has spent over $10 million; there must be $20 million or better in these four establishments.

Dr. GLENNAN. They will be, Mr. Daddario.

The point is, however, that if we are going to be concerned with the explorations of space, we are going to be concerned with the life sciences in space. We are not going to be able to monnitor, to usefully support work in other areas, in other laboratories such as the military laboratories, except we have competence on our own staff. The only way we well get competence on our own staff is to have a small research establishment where the people that we will be using in this area will also have their own laboratories. This is not a large buildup, although I quite realize the fear—a fear I share with you—

that once you start something it begins to grow. We don't envision this at all. Actually, in the use of the centrifuge at Johnsville, the monkey colonies at Brooks, the School of Aviation Medicine, these people have been particularly concerned with the problems of stress in flight, some sensory deprivation, that type of thing. They have not been concerned to any great extent with really basic studies of the biological type. And we think we must get into this area. There is no one doing this work.

* * * It seems to me almost impossible to simply say to the biomedical organizations in the Army and in the Navy and in the Air Force—"You worry about the life science area in space." They won't know where to start. They know what to do and they have known what to do as aircraft have become faster and have flown to greater heights. They have had to qualify their pilots. * * *

But in the broad sweep of the life sciences, I think there isn't any question but someone has to do this and we believe that we can't duck that responsibility, sir.

Mr. DADDARIO. Dr. Glennan, this is one of the problems which accentuates my fears in this whole area of bringing things together. Frankly, I cannot see why these four facilities cannot take the next step. I can't see why you couldn't hand them a requirement; why there should be so much difficulty in their finding a place to start. I think they already have started in this area. Why couldn't they carry out experiments within these facilities that you would request?

* * * I feel that it is duplication and waste, not only of facilities, but of funds. There ought to be more reason, from your standpoint than that they would not know where to start, or that they are not making progress in this area. I feel they are, and I think it is progress which you should take advantage of.

* * * isn't that the place for them to logically broaden themselves?

Dr. GLENNAN. They may not have the competence there. They have been concerned with fight problems.

Mr. DADDARIO. Well, then some of the testimony I have heard, I must have misinterpreted, because I have heard testimony as to their desire to develop a capacity and a competence with respect to future efforts into space.

Dr. DRYDEN. Let me try to clarify this, Mr. Daddario. They are concerned with what many of us call bioengineering, the engineering problems of getting a man in space. You are talking mainly about what is called bioscience, the underlying scientific work which is applied in the bioengineering. This is not something which the present staffs of these laboratories can do. * * *

Now, we are going to continue to use the service laboratories. The estimate is that three-quarters of our effort in this field will always be in the universities and service laboratories. I don't know whether this makes it any clearer or not (pp. 83–86).

* * * * *

B. Testimony of William M. Holaday, Chairman, Civilian-Military Liaison Committee

Mr. Holaday. * * *

Since the passage of the Space Act on July 29, 1958, the Civilian-Military Liaison Committee has met 13 times. The first meeting was held on November 25, 1958, and the last, on December 8, 1959. For the most part, the items of business brought before the Committee at the formal meetings are of the information type to keep the Committee, as a whole, informed on the activities of NASA and DOD in the fields of aeronautical and space research and development. The formal actions of the Committee are few in number.

* * * the committee is only one of the channels for insuring the exchange of information between NASA and DOD and as indicated by the above formal actions the role of the committee has been of relative minor importance. This status of the committee, I might add, had caused some concern on the part of the members.

* * * Actually, coordination between the agencies usually requires a decisionmaking capability which is the definite responsibility of management.

This committee, because of its composition, that is, a membership made up of representatives who are subject to a higher internal authority, is incapable of making firm decisions (pp. 90–91).

* * * * *

C. Testimony of James H. Douglas, Deputy Secretary of Defense

Mr. Daddario. * * * The thing that bothers me especially in this aerospace medicine field that we touched on before is, you have given a statement here today that you have met with NASA, and you have cautioned them against duplication in this particular field.

And when they appeared before this committee, their position was that there was no duplication in this field of aerospace medicine, and that they needed a competence of their own.

It is my belief you have within the Air Force a particularly good area of responsibility that you should keep, and that NASA ought to handle their responsibilities in this area by giving you their requirements, and that you should then carry them out and give them the results. We should not be spending additional moneys for additional buildings, for additional salaries in this particular area.

Secretary Douglas. I think that they are likely to delegate responsibility or to delegate activities in the field to a very large extent, but I agree with NASA that they have to have some competence in their own shop to plan requirements and to apply critical judgment to the work that is done for them. They have the responsibility at the present time of putting man in space.

Now, I think that when that is their primary responsibility, they can get the Defense Department actually to operate the launching system, the range, support, and recovery, but they still have a responsibility, and they cannot perform that responsibility unless they have competence within their own organization.

I would hope that it would be a relatively small group that provided that competence in the field you are talking about (p. 161).

* * * * *

D. Testimony of Vice Adm. John T. Hayward, Deputy Chief of Naval Operations (Development)

Mr. Daddario. * * * who would decide or who should decide whether or not NASA should also get into the field of aerospace medicine?

Admiral Hayward. This is a real good question. I would say offhand that they should not get into it. The Department of Defense will do any of the aerospace medicine that they need. There are people involved and we have the people and the facilities and the doctors involved in the work, both in the Air Force, in the Navy, and the Army. I think that the decision between the Secretary of Defense and Dr. Glennan would be that the Department of Defense would do it, that NASA would not get in it.

Mr. Daddario. Then as you see it, and looking into the future, if NASA has any requirements in this area, all it would have to do would be to hand them over to the Department of Defense, and the Department of Defense, utilizing its present facilities could take care of them?

Admiral Hayward. Yes, sir, and we would. For instance, Johnsville has been used every bit as much by the Space Agency as by ourselves. * * *

Mr. Daddario. And if NASA were to build a facility of its own, or if it had the desire to build a facility of its own and add people within this particular area, would we not be getting into the area of duplication?

Admiral Hayward. Yes, sir. Actually, I do not think it would make good sense. What happens when you build something new like that, our people will get better jobs over there, they will get higher civil service ratings, things of this kind. We would lose our people, too, and as a result, the overall effort would suffer (p. 185).

* * * * *

E. Testimony of Lt. Gen. Arthur G. Trudeau, Chief of Research and Development, Department of the Army

Mr. Daddario. * * *.

Now, I'd like to get your ideas on how we might resolve a problem:

During the last few days we have had testimony involving aerospace medical research. NASA feels it ought to have an

aerospace medical center, and has appointed a director of a department which will include within it this responsibility.

The Deputy Secretary of Defense, Mr. Douglas, has said he thinks they ought to have such a section.

Admiral Hayward said yesterday that he believes that the medical facilities which now exist within the Department of Defense, Navy, Air Force, et cetera, are sufficient to take care of our requirements, both present and future, and that NASA does not need to establish such facilities; he believes that it would be duplication if they have it, and that what should be done is that NASA should pass its requirements to the Department of Defense to handle within these existing facilities. * * * How do we resolve this particular problem? Who resolves it? Who makes the decision? How would it be done?

General TRUDEAU. * * *

We have been able and we are proud to have been able to afford NASA a space competency by virtue of their acquisition of the Army's space agencies, and perhaps this is the same way that they will acquire the aeromedical bases. In the services we have had a very considerable capability, and we have made these tests with primates, as you know. I still think there is a real medical problem involved here, because I am sure that the first man and perhaps most all of the men that go to space in the initial days are probably going to be people who have raised their hand in the defense of their country and wear their country's uniform, whatever kind of uniform you put on in a capsule (pp. 203–204).

* * * * *

F. TESTIMONY OF LT. GEN. BERNARD A. SCHRIEVER, COMMANDER, AIR RESEARCH AND DEVELOPMENT COMMAND, DEPARTMENT OF THE AIR FORCE

Dr. DADDARIO. You have said, General Schriever, that we are preoccupied too much with duplication. You said that today, and on other occasions.

General SCHRIEVER. That is right.

Mr. DADDARIO. Now, what is the present capacity of the Air Force in the field of aerospace medical research?

General SCHRIEVER. We have a considerable capacity there. We have in the order of 1,200 scientists in this field. We have laboratories at Wright Field. We have a great deal of activity going on at Holloman, also at Brooks Air Force Base in Texas. We have long been involved in the aeromedicine area. I think that—I would say it is a fair statement that the Air Force has pioneered in the aeromedicine or life sciences area.

Mr. DADDARIO. * * * who will settle the question whether the Air Force or NASA should handle aerospace medical research. NASA is setting up an agency or a capacity or a competence of its own in this particular area. Should they, or should they not have it? Who should decide? Why can

it not be kept within the Department of Defense? Why cannot NASA set its requirements, and give them to Defense to be developed?

General SCHRIEVER. Well, let me say this, that I did not mean to infer that there would never be any differences. There certainly will be some. I do not think there will be many. We have worked with the old NACA for years in this area. We have supported them in the aerospace or life sciences area. We are supporting them in this area completely in the Project Mercury, for example.

I personally feel that the setting up of a life sciences organization of a large scale in terms of facilities and resources in NASA should be looked at very carefully. It has not been brought to my level for coordination * * * (pp. 244–245).

* * * * *

[Excerpt from Senate hearing]

NASA OFFICE OF LIFE SCIENCES COULD DUPLICATE MILITARY MEDICAL RESEARCH

Senator YOUNG. My question is this. NASA has just organized a new Office of Life Sciences to do research in space medicine. Now, General, is that not a duplication that will cause additional expense to our taxpayers, an absolute duplication of the Air Force biomedical research activities?

General SCHRIEVER. It could be. I have discussed this with Mr. Horner. We are going to have some meetings. It depends entirely to what extend and what degree they build this Office up. I know that at least it is not his intention—I have not talked to Dr. Glennan about this—it is not his intention to duplicate. I think they need to have an office. But I think it should be essentially a staff element, and not try to duplicate all the laboratory and other facilities and resources that we have in the military.

Senator YOUNG. But you do have a very adequate Air Force medical research activity, and you do believe that that should not be duplicated, do you not?

General SCHRIEVER. I certainly believe that. I think we need to expand ourselves to some extent.

We have to have it in the military. We have to marry the man to the machine. And we simply have to have it.

Senator YOUNG. Do you believe it would be far cheaper and more effective if you were permitted to expand your medical research activities, rather than have NASA duplicate your facilities and activities?

General SCHRIEVER. I think so * * *(pp. 548–549).

* * * * *

PART V. OTHER RELATED ORGANIZATIONS AND PROGRAMS

1. National Academy of Sciences-National Research Council

The National Academy of Sciences-National Research Council is a private, nonprofit organization of over 550 scientists, dedicated to the furtherance of science and to its use for the general welfare. Membership is by election only and is in recognition of research accomplishments.

The Academy itself was established in 1863 under a congressional charter signed by President Lincoln. Empowered to provide for all activities appropriate to academies of science, it was also required by its charter to act as an adviser to the Federal Government in scientific matters. This provision accounts for the close ties that have always existed between the Academy and the Government, although the Academy is not a governmental agency.

The National Research Council was established by the Academy in 1916, at the request of President Wilson, to enable scientists generally to associate their efforts with those of the limited membership of the Academy in service to the Nation, to society, and to science at home and abroad. Members of the National Research Council receive their appointments from the president of the Academy. They include representatives nominated by the major scientific and technical societies, representatives of the Federal Government, and a number of members at large. More than 3,000 of the foremost scientists of the country cooperate in the work of the Academy-Research Council through service on its many boards and committees in the various fields of the natural sciences which fall within the eight divisions of the Academy-Research Council—Anthropology and psychology, biology and agriculture, chemistry and chemical technology, Earth sciences, engineering and industrial research, mathematics, medical sciences, and physical sciences. Other offices of the Academy-Research Council include Office of Scientific Personnel, Office of International Relations, and Pacific Science Office.

Receiving funds from both public and private sources by contribution, grant, or contract, the Academy and its Research Council thus work to stimulate research and its applications, to survey the broad possibilities of science, to promote effective utilization of the scientific and technical resources of the country, to serve the Government, and to further the general interests of science.

A. SPACE SCIENCE BOARD

National Academy of Sciences Establishes Space Science Board

[Press release of Aug. 3, 1958, from the National Academy of Sciences-National Research Council]

Washington, D.C., August 2.—Dr. Detlev W. Bronk, president of the National Academy of Sciences-National Research Council, announced today the formation of a 16-man Space Science Board, "to survey in concert the scientific problems, opportunities and implications of man's advance into space."

Dr. Lloyd V. Berkner, president of Associated Universities, Inc., president of the International Council of Scientific Unions and a member of the National Academy of Sciences, has been named chairman.

The Board, besides acting as the focal point for all Academy-Research Council activities connected with space-science research, will be called upon to coordinate its work with appropriate civilian and Government agencies, particularly the National Aeronautics and Space Administration, the National Science Foundation, and the Advanced Research Projects Agency, and with foreign groups active in this field.

In making the announcement, Dr. Bronk stated, "We feel that the formation of this Board can have especial significance for science as we face the challenge and adventure of the new steps into space that are surely and swiftly on the way. It is my hope that the Board will give fullest possible attention to every aspect of space science, including both the physical and the life sciences. I believe that the Academy-Research Council has a unique opportunity to bring together scientists from many fields to find ways to further a wise and vigorous national scientific program in this field."

The functions of the Board will include studies of scientific-research opportunities and needs opened up by the advent of modern rocket and satellite tools, advice and recommendations on space science to interested agencies and institutions, stimulation of research interest in the rocket and satellite fields, and cooperative activities in this area with academies and similar institutions abroad.

Eleven ad hoc committees have already been organized to carry on the work of the Board under Dr. Berkner's leadership. These committees, together with their chairmen and vice chairmen (who comprise the membership of the Board), follow:

1. Geochemistry of Space and Exploration of Moon and Planets: chairman, Dr. Harold C. Urey, professor of chemistry, University of California, La Jolla; vice chairman, Dr. Harrison S. Brown, professor of geochemistry, California Institute of Technology.

2. Astronomy and Radio Astronomy: Chairman, Dr. Leo Goldberg, chairman, Department of Astronomy, University of Michigan.

3. Future Vehicular Development (beyond vehicles immediately available and including possible space stations and interplanetary vehicles for scientific research): Chairman, Dr. Donald F. Hornig, professor of chemistry, Princeton University.

4. International Relations Field (coordination with International Council of Scientific Unions and other national scientific bodies on problems in international sharing of payloads, international cooperation in space activities and advice on the formulation and effects of regulatory policies): Chairman, Dr. W. A. Noyes, dean, College of Arts and Sciences, University of Rochester.

5. Immediate Problems (space laboratories, orbits, currently feasible research projects, and liaison with the technical panel on the earth satellite program of the U.S. National Committee for the International Geophysical Year during terminal phases of IGY): Chairman, Dr. R. W. Porter, chairman of the USNC–IGY Technical Panel on the Earth Satellite Program, and consultant—communication and control, engineering services, General Electric Co., New York.

6. Space projects (analysis of advanced space research proposals and long-range planning): Chairman, Dr. Bruno B. Rossi, professor of physics, Massachusetts Institute of Technology.

7. Ionosphere (experiments pertaining to auroral and ionospheric effects, including whistlers and special propagation phenomena): Chairman, Mr. A. H. Shapley, physicist, National Bureau of Standards, Boulder, Colo.

8. Physics of Fields and Particles in Space: Chairman, Dr. John H. Simpson, professor of physics, University of Chicago; vice chairman, Dr. James A. Van Allen, head, Department of Physics, State University of Iowa.

9. Future Engineering Development Beyond Available Facilities (telecommunications, telemetry, guidance, environmental conditions and advanced laboratory requirements): Chairman, Dr. O. G. Villard, Jr., professor of electrical engineering, Stanford University.

10. Meteorological Aspects of Satellites and Space Research: Chairman, Dr. Harry Wexler, director of meteorological research, U.S. Weather Bureau.

11. Psychological and Biological Research: Chairman, Dr. H. Keffer Hartline, Biophysics Section, Rockefeller Institute for Medical Research; vice chairman, Dr. S. S. Stevens, professor of psychology, Harvard University.

A twelfth committee, on geodesy, will be chaired by a Board member still to be selected.

In describing how the Board would seek to accomplish its tasks, Dr. Berkner said, "To insure the development of U.S. space science on a broad base, we shall encourage the participation of scientists from universities and private research institutions. While Government participation is essential, we

feel that it would be unwise if space science were to be developed entirely within the bounds of Government activity.

"We shall also encourage broad participation from all fields of science in order to offer useful guidance to all groups engaged in space-science research, suggesting—when advisable—the integration of similar proposals and the elimination of those that are inappropriate."

Still another task before the Board would be a program to gain the further cooperation of the International Council of Scientific Unions and other international organizations in the prevention of undesirable and unnecessary contamination of moon and planet surfaces and atmosphere with alien particles of energy and matter introduced from earth by space vehicles.

Named as Executive Director of the new Board was Dr. Hugh Odishaw, who also serves the Academy-Research Council as Executive Director of the U.S. National Committee for the IGY. A permanent staff will be recruited to serve as a secretariat.

Although it is a private agency, the National Academy of Sciences-National Research Council is obliged, under the terms of a congressional charter signed in 1863 by Abraham Lincoln, to advise the Government, upon request, on any matters of scientific or technical interest. A nonprofit organization of distinguished scientists from all branches of natural science, the Academy-Research Council is dedicated to the furtherance of science and its use for the general welfare.

Space Science Board Report of Activities, January–December 1959

The Space Science Board was established by the National Academy of Sciences in mid-1958 in response to national and international basic research interests.

Domestically, the Board serves in an advisory capacity to agencies of the Federal Government having executive responsibilities in the field of space science. These agencies are the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Department of Defense (DOD). Because NASA and NSF have primary responsibility for civilian space science, the relations of the Board to these agencies have been particularly close, and the Board is supported by these two institutions. The Board has provided advice and recommendations on a variety of subjects relating to basic research; it has served to represent the interests of scientists broadly; and, it has sought to provide a broad scientific base for current and future U.S. space science efforts by stimulating the interests of leading scientists in space and by affording a forum for discussion of research problems to the scientific community.

Internationally, the Board serves as the Academy's vehicle for cooperation with scientists of other countries. The ve-

hicle for such cooperation is the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU). Adherence to this committee is effected by the Academy through the Board's Committee on International Relations, whose chairman serves as the delegate to COSPAR. The Board, its committees, and Academy staff have devoted considerable effort to problems of international cooperation during 1959.

The members of the Board serve as chairmen of 13 specialized subcommittees covering the various scientific disciplines and fields of activity associated with the country's space science program. The Board and its committees are composed of approximately 140 leading specialists. Since its formation, the Board and its committees have had 23 formal meetings and even a larger number of informal sessions.

NATIONAL ACTIVITIES

Space research proposals.—Immediately upon its establishment the Board solicited proposals and suggestions from the national scientific community for additional projects in space science research which should follow upon the accomplishment of the IGY satellite and rocket program. The Board's committees assessed some 200 proposals and provided recommendations concerning these projects to the NASA and the NSF in the fall of 1958 and early 1959. These studies proved especially valuable by enabling the NASA, promptly upon its establishment, to organize the initial program of post-IGY space research which is now being conducted. These activities of the Board provided for an orderly transition from the IGY period, under direction of the Academy's IGY Satellite Panel, to the post-IGY effort.

The committees of the Board continue to function on behalf of the NASA as scientific disciplinary committees for review and formulation of the program objectives of the NASA national space sciences program.

Review of space research programs.—During 1959 the Board held three major meetings: January 17–20 at the Atlantic Missile Range, Cape Canaveral, Fla.; May 7–9 at NASA headquarters and the Advanced Research Projects Agency, Washington, D.C.; and October 23–24 in Philadelphia. At each of these meetings the Board has received comprehensive reviews of the current and immediate future programs of research in space science by senior officials of the NASA, the National Science Foundation, and agencies of the Department of Defense. Following a pattern developed in 1958, when the Board met at the Army Ballistic Missile Agency, Huntsville, Ala., and the Air Force complex of laboratories and selected contract facilities in the Los Angeles area, these visits have served to orient Board members in such matters as the vehicular programs underway, the launching facilities available to scientists, and the complexities involved in launching a space experiment. Particularly,

at each of these meetings the Board has examined the current national programs of space research as presented by the senior officials of the NASA, the National Science Foundation, and the Department of Defense to ascertain the state of the research being conducted, the major problems requiring solution for optimum scientific progress, and the means whereby more broadly to draw upon the talents of scientists throughout the Nation in the conduct of this research.

Symposia.—Jointly with the NASA and the American Physical Society, the Board sponsored a discussion symposium in Washington on the exploration of space on April 29–30, 1959. Organized in three sessions, the symposium reviewed space research findings to that time and discussed the broad objectives of future research programs in all fields of space science. Attended by about 1,000 scientists from the whole country, the symposium provided significant stimulus to the scientific community by presenting recent space science results, by reviewing the current status of space science, and by exploring scientific objectives and opportunities in space research. Proceedings of the symposium have been published in the Journal of Geophysical Research, volume 64, No. 11, November 1959, and will soon be available in book form.

"*Science in Space*".—During 1959 the Board prepared a volume, "Science in Space," which broadly examines the opportunities and objectives of space science for the coming years. This volume, whose chapters are written by eminent U.S. scientists in various fields, covers such subjects as the nature of gravitation, geodetic measurements, and continental distances, meteorology, physics of the earth's upper atmosphere, the moon and planets, the solar system and galactic astronomy, physics of fields and energetic particles in space, and space biology. Scheduled for publication in early 1960, the volume outlines major areas of fundamental scientific research toward which the national space effort should be directed, indicating the general objectives of a national space program and suggesting to scientists the opportunities and challenges of this vast new area of study.

Special problems.—Under the auspices of the Space Science Board a number of special ad hoc study committees were established to consider on behalf of scientists specific problems or neglected areas affecting space research. Among these have been the consequences of contamination of extraterrestrial bodies by impacting space probes and recommendations for a program to prevent this contamination; the need for exclusive allocations of radio frequencies for use in space research (specific recommendations were provided to the U.S. delegation to the 1959 International Telecommunication Union Conference in Geneva); ground-based radar astronomy which should be conducted to provide backup support to the space sciences program; the photochemical aspects of space exploration; the chemical analysis of meteorites contributory to future space experimentation.

Rocket and Satellite Data Center.—Established during the IGY, this center provides a means for international exchange of scientific data resulting from rocket and satellite programs. Through this Academy center, announcements of launchings have been made available to observers throughout the world for tracking purposes, summary descriptions of space programs have been made available, and two series of reports have been issued. One series deals with sounding rocket research results; the other with satellite and space probe findings. To date, five reports have been issued in the Rocket Series and nine reports in the Satellite Series; several additional reports in both series were in final steps of preparation.

During 1959 the following rocket reports were issued: No. 2, "Flight Summaries for the U.S. Rocketry Programs for the IGY," part I, July 5, 1956, to June 30, 1958, 193 pages; No. 3, "Flight Summaries for the U.S. Rocketry Program for the IGY," part II, May 23, 1958, to December 31, 1958, 129 pages; No. 4, "Magnetic Exploration of the Upper Atmosphere," 86 pages; and No. 5, "Upper Air Densities and Temperature From Eight IGY Rocket Flights by the Falling-Sphere Method," 102 pages.

At the same period the following satellite reports were isuued: No. 7, "Simplified Satellite Prediction From Modified Orbital Elements," January 1, 1959, 54 pages; No. 8, "Ephemeris of Satellite 1957 Alpha 2 and Collected Reports on Satellite Observations," June 15, 1959, 122 pages; and No. 9, "Symposium on Scientific Effects of Artificially Introduced Radiations at High Altitudes," September 15, 1959, 87 pages.

Several additional volumes in each series are in preparation for issuance early in 1960.

The center has also maintained an archive of results and documents from other countries. The center has acquired some 1,000 reports and published papers. These were collated during the last quarter of 1959, looking forward to preparation and issuance of a series of reports which would provide orderly information on space vehicles, bibliographies, and résumés of papers, ordered by vehicles and principal subject areas.

INTERNATIONAL ACTIVITIES

Committee on Space Research.—In accord with the National Academy of Sciences adherence to the International Council of Scientific Unions (ICSU), the Space Science Board provides U.S. representation to the ICSU Committee on Space Research (Cospar). Cospar, organized in October 1958, affords the means for international scientific collaboration in space science. Dr. R. W. Porter, chairman of the Board's Committee on International Relations, is the U.S. representative to Cospar. Cospar represents a most effective means for international consideration among scientists of the broad objectives of space research, affords an effective forum

for international discussion of these topics, and promotes international collaboration in operational space research programs.

The NASA has made use of the Academy's Board and Cospar as effective channels for international participation in the U.S. space science program. For example, the March 1959 meeting of Cospar afforded the opportunity for the NASA, through the U.S. Cospar representative, to extend to international science an invitation to participate in its program; through this channel NASA has offered to fly space experiments developed in other countries and to launch on behalf of Cospar an internationally instrumented satellite. The NASA offer to Cospar has already contributed to increased interest by scientists of several countries in conducting space experiments.

Cospar Rocket Week.—On behalf of Cospar the Board and its staff developed the U.S. contribution to an internationally coordinated program of rocket soundings of the upper atmosphere for scientific purposes, November 16–22, 1959. The U.S. program included 10 rockets launched by 3 scientific institutions in this country. The Board has also participated in development of plans for a Cospar Rocket Week in 1960, and it is anticipated that this program will become an annual event.

First International Space Science Symposium.—In connection with plans for the Cospar First Annual International Space Science Symposium, the Board and its staff have developed the U.S. scientific contributions. This symposium, directed toward a review of space science achievements to date and an examination into immediate future possibilities in this field, promises to be a most significant and important scientific event. Scheduled to be held at Nice, France, January 11–15, 1960, the Cospar symposium will include approximately 100 papers contributed by scientists from many nations, with international participation numbering perhaps 400 individuals. The present U.S. contribution involves some 40 or more scientific papers of outstanding merit and an Academy delegation from the United States of approximately 75 scientists.

United Nations.—The Board and its staff have cooperated with the NASA and the U.N. Secretariat in providing information and advice on space science activities during the IGY and thereafter. Upon request of the U.S. delegation to the U.N. Ad Hoc Committee on Peaceful Uses of Outer Space, a member of the Board was made available to assist the delegation by providing scientific advice and assistance during the Committee's deliberations.

SPACE SCIENCE BOARD DIRECTORY, JANUARY 1, 1960

Dr. Lloyd V. Berkner, Chairman; president, Associated Universities, Inc.

Dr. Harrison S. Brown, Division of Geological Sciences, California Institute of Technology.

Dr. Leo Goldberg, Department of Astronomy, University of Michigan.
Dr. H. Keffer Hartline, Rockefeller Institute.
Dr. Donald F. Hornig, Department of Chemistry, Princeton University.
Dr. William W. Kellogg, RAND Corp.
Dr. Joshua Lederberg, School of Medicine, Stanford University.
Dr. Richard W. Porter, General Electric Co.
Dr. Bruno B. Rossi, Department of Physics, Massachusetts Institute of Technology.
Alan H. Shapley, Central Radio Propagation Laboratory, National Bureau of Standards.
Dr. John A. Simpson, Enrico Fermi Institute for Nuclear Studies, University of Chicago.
Dr. S. S. Stevens, Psycho-Acoustic Laboratories, Harvard University.
Dr. Harold C. Urey, University of California.
Dr. James A. Van Allen, head, Department of Physics, State University of Iowa.
Dr. O. G. Villard, Jr., Department of Engineering, Stanford University.
Dr. Harry Wexler, U.S. Weather Bureau.
Dr. George P. Woollard, professor of geology, University of Wisconsin.

Invited participants:

George P. Sutton, Chief Scientist, Advanced Research Projects Agency.
Dr. Hugh L. Dryden, Deputy Administrator, National Aeronautics and Space Administration.
Dr. T. Keith Glennan, Administrator, National Aeronautics and Space Administration.
Dr. Richard H. Bolt, Associate Director (Research), National Science Foundation.
Dr. Randall Robertson, Assistant Director for Mathematical, Physical and Engineering Sciences, National Science Foundation.
Jesse L. Mitchell, President's Science Advisory Committee.
Dr. Alan T. Waterman, Director, National Science Foundation.

Secretariat:

Dr. Hugh Odishaw, Executive Director.
R. C. Peavey, secretary.
George A. Derbyshire.
Dr. Edward R. Dyer.
J. P. T. Pearman.
Stanley Ruttenberg.

Committee 11, Psychological and Biological Research

Membership:

Dr. H. Keffer Hartline, chairman; Rockefeller Institute.
Dr. S. S. Stevens, vice chairman; Psychological Laboratories, Harvard University.
Dr. Howard J. Curtis, Department of Biology, Brookhaven National Laboratories.

Dr. L. E. Farr, Department of Medicine, Brookhaven National Laboratories.
Dr. Thomas Francis, Department of Epidemiology, University of Michigan.
Dr. Joshua Lederberg, Department of Genetics, Stanford University.
Dr. E. F. MacNichol, Department of Biophysics, Johns Hopkins University.
Dr. Otto H. Schmitt, Department of Biophysics, University of Minnesota.
Dr. Edward L. Tatum, Department of Biochemical Genetics, Rockefeller Institute.

Liaison representatives:

Dr. Clark Randt, Director, Office of Life Science Programs, National Aeronautics and Space Administration.
Dr. John T. Wilson, Assistant Director for Biological and Medical Sciences, National Science Foundation.

B. ARMED FORCES—NATIONAL RESEARCH COUNCIL COMMITTEE ON BIO-ASTRONAUTICS

ACADEMY-RESEARCH COUNCIL, ARMED FORCES JOIN IN STUDY OF BIOLOGICAL EFFECTS OF SPACE FLIGHT

[Press release of Feb. 9, 1959, from the National Academy of Sciences-National Research Council]

WASHINGTON, February 8.—The National Academy of Sciences-National Research Council announced today the organization of the Armed Forces-National Research Council Committee on Bio-Astronautics. The Committee will advise the Armed Forces, upon their request, in any matter concerning the biological or medical aspects of space exploration.

Policy decisions and the programing of activities within the Committee will be the responsibility of an Executive Council. The following scientists—representing different fields of endeavor in universities, private research organizations, and the Armed Forces—have been appointed to the Executive Council by Dr. Detlev W. Bronk, President of the Academy-Research Council: Chairman, Dr. Otto H. Schmitt, Department of Physics, University of Minnesota; Vice Chairman, Dr. Melvin Calvin, Department of Chemistry, University of California, Berkeley; Dr. Howard J. Curtis, Department of Biology, Brookhaven National Laboratory; Dr. Paul M. Fitts, Department of Psychology, University of Michigan; Brig. Gen. Don D. Flickinger, Directorate of Life Sciences, Air Research and Development Command; Dr. John D. French, Department of Anatomy, University of California Medical Center, Los Angeles; Capt. Charles F. Gell, Office of Naval Research; Dr. James D. Hardy, U.S. Naval Air Development Center, Johnsville, Pa.; and Col. Robert H. Holmes, Research and Development Command, Office of the Surgeon General, Department of the Army.

The full Committee on Bio-Astronautics—which will consist of more than 100 members, of whom at least half will be nominees of the Armed Forces—will serve as a conference or forum of active investigators, meeting periodically to review scientific and technical problems, exchange information, and establish liaison between investigators with allied interests.

Administrative responsibility for the Committee has been vested within the Academy-Research Council's Division of Medical Sciences, whose chairman is Dr. R. Keith Cannan. Acting executive secretary to the Committee is Dr. Sam F. Seeley; previous to his retirement after 31 years of Army service, Dr. Seeley had been Chief of the Professional Division in the Office of the Surgeon General. Both Dr. Cannan and Dr. Seeley participate in Executive Council meetings as ex-officio members. The third ex-officio member is Maj. Kay Cutler, Air Research and Development Command. Assigned to serve as assistant executive secretary has been Lt. Col. Clarence Cain, USAF, formerly Chief of the Bio-Medical Division, Directorate of Life Sciences, Air Research, and Development Command.

At a recent organization meeting, the Executive Council agreed to the following goals:

1. Acquainting scientific investigators with the military requirements for establishing space as an operational medium for man.
2. Considering and reporting upon military problems related to manned space operations.
3. Assisting in providing scientists and military personnel with access to scientific and technical information pertaining to the bioastronautical problems of life in space.
4. Promoting the exchange of research information on bioastronautical problems through such media as meetings, symposia, and forums.
5. Stimulating research on all problems of life in space where deficiencies of knowledge warrant special effort.
6. Furthering the science of bioastronautics by encouraging the contributions of the many related fields of science.
7. Providing specific answers to specific problems posed by the Armed Forces.

The Committee will concern itself with any field of science or of technology that it finds necessary in pursuit of its objectives, including pertinent aspects of astronautics, biology, chemistry, medicine, physiology, psychology, and related interdisciplinary sciences. Specific examples are:

1. Closed-system environments.
2. Stress.
3. Crew selection, motivation, surveillance and control, including group dynamics.
4. Ground support facilities.
5. Weightlessness—physiological and psychological aspects.
6. Metabolic requirements, including nutrition, water balance, electrolyte balance, etc.

7. Cosmic and other forms of radiation.
8. Isolation and confinement.
9. Displays, controls, and communication.
10. Acceleration, deceleration, and vibration.
11. Escape and survival.
12. Orientation.
13. Man-machine-systems problems.

The Armed Forces—NRC Committee on Bio-Astronautics, supported under the terms of a contract between the Air Force and the National Academy of Sciences, bears close resemblance in structure to similar Armed Forces-NRC Committees on Vision and Bio-Acoustics, both of which have been functioning for several years under the Academy-Research Council Division of Anthropology and Psychology.

The National Academy of Sciences-National Research Council is a private, nonprofit organization of distinguished scientists dedicated to the furtherance of science and its use for the general welfare. Although it is not a governmental organization, the Academy-Research Council has long enjoyed a close association with many Government agencies; its congressional charter, signed in 1863 by President Abraham Lincoln, calls upon the Academy to advise the Government, upon request, in all matters of scientific and technical interest.

* * * * *

STATEMENTS OF PANEL MISSIONS

1. *Panel on Information.*—The Panel on Information is responsible for keeping informed of the activities of each of the 10 panels and of the Executive Council. Each panel is assigned the task of listing those scientific fields for which it assumes responsibility. An analysis of such information provides the Panel on Information with scientific areas of concern to the entire committee, thus defining those areas of primary interest and indicating fringe areas requiring informational exchange. Its goal is to make available all possible information, to be alert to the necessity of avoiding duplication, and to discover and clarify, or prevent, conflict of views or opinions.

2. *Panel on Extraterrestrial Life.*—The purpose of this panel is to explore the possibilities for finding a definitive answer to the question of whether there is life anywhere besides on earth. The technological capability of traveling away from the earth's surface makes this a reasonable possibility. The actual steps to be taken are to be decided by the panel.

3. *Panel on Closed Ecological Systems.*—The primary mission of this panel shall be to help determine what basic information is available and needed to permit the design, construction, and maintenance of a closed ecological system containing one or more humans.

4. *Panel on Bioinstrumentation.*—The Panel on Bioinstrumentation will concern itself not only with the problems of instrumentation incidental to space exploration and its supportive research but will also consider within its province those parts of biological phenomenology and analytical technical processes having to do with in-

formational transmission and conveying, data reduction and processing, and control systems.

5. *Panel on Acceleration Stress.*—This panel is concerned with research and development problems in the physiological and psychological effects of, and tolerance and performance under, acceleration stresses.

6. *Panel on Biological Orientation and Navigation.*—The mission of the biological orientation panel includes: (*a*) an examination of various organisms—aerial, terrestrial, and aquatic—which exhibit unique abilities of direction finding, as well as time sense, translated into terms relevant to the field of bioastronautics; and (*b*) a resolution of the controversies that have arisen within the last decade regarding the mechanisms by means of which organisms are able to carry out these functions.

7. *Panel on Psychology.*—This panel will be concerned with the behavior and performance of human beings in space flights, as well as of the animals which will precede man into space, including those laboratory and simulated space experiments which make contributions to astronauts, as well as the collection of data from true space flight missions.

8. *Panel on Radiation Biology.*—The functions of this panel are to collect and evaluate all information concerning the radiation hazard in satellite and interplanetary travel; to explore radiation areas needing further laboratory research; and to recommend radiation experiments to be undertaken in satellites.

9. *Panel on Bioengineering of Protective Systems.*—The mission of the Panel on Bioengineering of Protective Systems of man in space flight is to outline the specific areas of requirement for protective systems for man in space flight both in the matter of individual biologic stressor or combined stressor mechanisms; to review and scrutinize the programs and effort of the military and their contractors engaged in the science of space flight insofar as the bioengineering of protective systems for man are concerned for the purpose of endorsing or constructively criticizing their overall concepts, extant programs and future planning; to function as a consulting panel of experts; and to make pertinent information in these areas known to appropriate agencies.

Executive Council

Schmitt, Dr. Otto H., Chairman; Biophysics Group, University of Minnesota.

Calvin, Dr. Melvin, Vice Chairman; Department of Chemistry, University of California.

Curtis, Dr. Howard J., Department of Biology, Brookhaven National Laboratory.

Fitts, Dr. Paul M., Department of Psychology, University of Michigan.

Flickinger, Brig. Gen. D. D., MC, Air Research and Development Command, Andrews Air Force Base.

French, Dr. John D., Medical Center, University of California.

Gell, Capt. Charles F., MC, Office of Naval Research, Department of the Navy.

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Hardy, Dr. James D., Aviation Medicine Acceleration Laboratory, Naval Air Development Center.
Taylor, Lt. Col. Richard R., MC, Army Medical Research and Development Command.
Alternate military members:
Holmes, Col. Robert H., MC, Armed Forces Institute of Pathology, Walter Reed Army Medical Center.
Houghton, Col. Karl H., MC, Office of Air Force Surgeon General.
Phoebus, Capt. C. P., MC, Bureau of Medicine and Surgery, Department of the Navy.
Ex officio members:
Cannan, Dr. R. Keith, Division of Medical Sciences, National Academy of Sciences-National Research Council.
Cutler, Maj. Kay, MC, Biomedical Division, Air Research and Development Command, Andrews Air Force Base.
Seeley, Dr. Sam F., Executive Secretary, Division of Medical Sciences, National Academy of Sciences-National Research Council.

Liaison Representatives to the Executive Council

Campbell, Dr. Frank L., Division of Biology and Agriculture, National Academy of Sciences-National Research Council.
Fenn, Dr. Wallace O., School of Medicine and Dentistry, University of Rochester.
Finch, Dr. Glen, Division of Anthropology and Psychology, National Academy of Sciences-National Research Council.
Livingston, Dr. Robert B., National Institute of Neurological Diseases and Blindness, National Institutes of Health.
Lovelace, Dr. W. Randolph, II, Chairman, NASA Life Sciences Committee.
Wilson, Dr. John T., Assistant Director for Biological and Medical Sciences, National Science Foundation.
Zelle, Dr. Max R., Division of Biology and Medicine, Atomic Energy Commission.

Panel on Information (Panel 1)

Byerly, Dr. T. C., Chairman; Agricultural Research Service, Department of Agriculture.
Pope, S. Edward, Vice Chairman; Armed Services Technical Information Agency.
Bandurski, Dr. Robert S., Botany Department, Michigan State College.
Bertalan, Frank., Office of Naval Research, Department of the Navy.
Bialecki, Adolph, Electric Boat Division, General Dynamics Corp.
Flickinger, Brig. Gen. D. D., MC, Air Research and Development Command, Andrews Air Force Base.
Goldsen, Joseph, The RAND Corp.
Gray, Dr. Dwight E., Office of Science Information Service, National Science Foundation.
Heim, Dr. J. W., Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Jacobius, Dr. Arnold J., Library of Congress.

Kennard, Dr. William J., Aerospace Medical Association.
Lee, Dr. Milton O., Federation of American Societies for Experimental Biology.
Singleton, Dr. W. Ralph, Department of Biology, University of Virginia.
Zwemer, Dr. Raymund L., Assistant Science Adviser, Department of State.

Liaison Representatives to the Panel on Information

Brodman, Dr. Estelle, National Library of Medicine, Department of Health, Education, and Welfare.
Phillips, Maj. Gen. James F. (retired), Aerospace Industries Association.
Shilling, Dr. C. W., Division of Biology and Medicine, U.S. Atomic Energy Commission.
Specht, Dr. Heinz, National Institute of Arthritis and Metabolic Diseases, National Institute of Health.
Voris, Dr. LeRoy, Food and Nutrition Board, National Academy of Sciences—National Research Council.

Panel on Extra-Terrestrial Life (Panel 2)

Calvin, Dr. Melvin, chairman; Department of Chemistry, University of California.
Vishniac, Dr. Wolf, vice chairman; Department of Biology, Brookhaven National Laboratory.
Davies, Richard W., Jet Propulsion Laboratory, California Institute of Technology.
Hutchinson, Dr. George E., Department of Zoology, Yale University.
Linschitz, Dr. Henry, Department of Chemistry, Brandeis University.
Lord, Dr. Richard C., Department of Chemistry, Massachusetts Institute of Technology.
Meselson, Dr. Matthew, Gates and Crellin Laboratories, California Institute of Technology.
Ross, Malcolm D., Office of Naval Research, Department of the Navy.
Sagan, Carl E., Yerkes Observatory, University of Chicago.
Weaver, Dr. Harold, Radio Astronomy Laboratory, University of California.

Panel on Closed Ecological Systems (Panel 3)

Gotaas, Dr. Harold B., chairman; Dean, Technological Institute, Northwestern University.
Lambertsen, Dr. Christian J., vice chairman; School of Medicine, University of Pennsylvania.
Berner, Dr. Fred W., Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Bialecki, Adolph, Electric Boat Division, General Dynamics Corp.
Brown, Dr. Allan H., Department of Botany, University of Minnesota.
Chinn, Dr. Herman I., Biological Sciences Division, Air Force Office of Scientific Research.

Hays, Edward L., Research and Development Division, Naval Air Material Center.
Henschel, Dr. Austin F., Environmental Protection Research Division, Army Quartermaster Research and Engineering Command.
Hursh, Col. L. M., MC, Army Medical Research and Development Command.
Jones, Capt. Walton L., Jr., MC, Bureau of Aeronautics, Department of the Navy.
Myers, Dr. Jack E., Department of Zoology, University of Texas.
Pipes, Dr. Wesley O., Department of Civil Engineering, Northwestern University.
Schaefer, Dr. Karl E., Naval Medical Laboratory, New London, Conn.
Syner, Maj. James C., MC, Fitzsimons Army General Hospital.
White, Lt. Col. Stanley, MC, Langley Research Center, National Aeronautics and Space Administration.
Yaglou, Prof. C. P., School of Public Health, Harvard University.

Panel on Bio-Instrumentation (Panel 4)

Schmitt, Dr. Otto H., Chairman; Biophysics Group, University of Minnesota.
Adey, Dr. Wm. R., Vice Chairman; Department of Anatomy, University of California at Los Angeles.
Clamann, Dr. Hans, School of Aviation Medicine, Brooks Air Force Base.
Cumming, Lawrence G., the Institute of Radio Engineers, Inc.
Kellogg, Dr. William W., the Rand Corp.
MacNichol, Dr. Edward F., Jr., Department of Biophysics, Johns Hopkins University.
Madsen, R. Glen, Convair-Astronautics Division, General Dynamics Corp.
Marbarger, Dr. John P., Aeromedical and Physical Environment Laboratory, University of Illinois.
McLennan, Miles A. Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Rosenblith, Dr. Walter, Department of Electrical Engineering, Massachusetts Institute of Technology.
Talbot, Dr. Samuel A., Johns Hopkins University Hospital.
Trank, Dr. John W., Medical School, University of Minnesota.
Wilbarger, Capt. E. S., Jr., MSC, Nuclear Power Division, Army Corps of Engineers.

Panel on Acceleration Stress (Panel 5)

Hardy, Dr. James D., Chairman; Aviation Medicine Acceleration Laboratory, Naval Air Development Center.
Clark, Dr. Carl C., Vice Chairman; Aviation Medicine Acceleration Laboratory, Naval Air Development Center.
Bates, George P., National Aeronautics and Space Administration.
Cappel, Klaus L., Laboratories for Research and Development, the Franklin Institute.

Galambos, Dr. Robert, Walter Reed Army Institute of Research, Walter Reed Army Medical Center.
Gerathewohl, Dr. Siegfried J., Medical Research Unit, Army Ordnance Missile Command.
Goldman, Comdr., David E., MSC, Naval Medical Research Institute.
Graybiel, Capt. Ashton N., MC, Naval School of Aviation Medicine.
Guedry, Dr. Frederick E., Psychology Division, Army Medical Research Laboratory.
Hessberg, Lt. Col. Rufus, Aeromedical Field Laboratory, Air Force Missile Development Center.
Hiatt, Dr. Edwin P., Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Meehan, Dr. John P., School of Medicine, University of Southern California.
von Gierke, Dr. Hennig, Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Wood, Dr. Earl H., Mayo Clinic.

Panel on Biological Orientation and Navigation (Panel 6)

Galler, Dr. Sidney R., Chairman; Office of Naval Research, Department of the Navy.
Bullock, Dr. Theodore H., Department of Zoology, University of California.
Griffin, Dr. Donald R., Biological Laboratories, Harvard University.
Harlow, Dr. Harry F., Department of Psychology, University of Wisconsin.
Pittendrigh, Dr. Colin S., Department of Biology, Princeton University.
Ross, Dr. Sherman, American Psychological Association.

Panel on Psychology (Panel 7)

Grether, Dr. Walter F., Chairman; Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Eckstrand, Dr. Gordon A., Vice Chairman; Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Bevan, Dr. William, Department of Psychology, Kansas State University.
Brown, Dr. John L., School of Medicine, University of Pennsylvania.
Carp, Dr. Abraham, Personnel Laboratory, Lackland Air Force Base.
Fitts, Dr. Paul M., Department of Psychology, University of Michigan.
Hauty, Dr. George T., School of Aviation Medicine, Brooks Air Force Base.
Lilly, Dr. John C., Communication Research Institute, St. Thomas, V.I.
Rioch, Dr. David McK., Walter Reed Army Institute of Research, Walter Reed Army Medical Center.
Ruff, Dr. George E., University Hospital, Philadelphia, Pa.
Senders, John W., Honeywell, Minneapolis, Minn.
Trumbull, Dr. Richard, Office of Naval Research, Department of the Navy.

Panel on Radiation Biology (Panel 8)

Curtis, Dr. Howard J., Chairman; Department of Biology, Brookhaven National Laboratory.
Haymaker, Dr. Webb E., Armed Forces Institute of Pathology, Walter Reed Army Medical Center.
Pickering, Col. John E. (MC), School of Aviation Medicine, Brooks Air Force Base.
Schaefer, Dr. Herman J., Radiation Biophysics, Naval School of Aviation Medicine.
Tobias, Dr. Cornelius A., Donner Laboratory, University of California.
Yagoda, Dr. Herman, Geophysics Research Directorate, Air Force Cambridge Research Center.
Zelle, Dr. Max, Biology Division of Biology and Medicine, Atomic Energy Commission.

Panel on Bioengineering of Protective Systems (Panel 9)

Gell, Capt. C. F. (MC), Chairman; Office of Naval Research, Department of the Navy.
Mayo, Alfred M., Vice Chairman; Douglas Aircraft Co., Inc.
Bollerud, Col. Jack (MC), Air Research and Development Command, Andrews Air Force Base.
Bosee, Capt. Roland A., MSC, Air Crew Equipment Laboratory, Naval Air Material Center.
Clark, David, David Clark Co., Inc.
Holmes, Col. Robert H. (MC), Armed Forces Institute of Pathology, Walter Reed Army Medical Center.
Johnston, Richard S., Jr., Life Systems Branch, NASA Langley Research Center.
Jones, Capt. Walton L., Jr. (MC), Bureau of Aeronautics, Department of the Navy.
Lowry, Dr. Romney H., Space Medicine Branch, Boeing Airplane Co.
Lund, Dr. Max W., Office of Naval Research, Department of the Navy.
Martin, Ernest E., Aerospace Medical Laboratory, Wright-Patterson Air Force Base.
Stapp, Col. John P. (MC), Chief, Aerospace Medical Laboratory, Wright-Patterson Air Force Base.

2. National Science Foundation

In the President's second annual report to the Congress on U.S. Aeronautics and Space Activities, covering the calendar year 1959, the role of the National Science Foundation in space activities was described as follows:

> One of the principal objectives of the National Science Foundation (NSF) is to support basic research of a pioneering nature in all areas of science. In the main, this is done through grants to nonprofit institutions for the support of research projects proposed by staff scientists of the institutions involved. A few special grants and contracts have been let for the development of special instrumentation or facilities which are deemed particularly important for the advancement of research in particular fields. A substantial part of these efforts is devoted to the support of scientific investigations that seek an understanding of the fundamental laws of the physical universe.
>
> *Basic science programs related to space*
>
> *NSF encourages work in underemphasized but important areas.*—In the areas of space science, NSF activity consists primarily in supporting basic research which contributes to an understanding of the physical and biological processes occurring in the space environment. An effort is made by NSF to give particular encouragement to needs of the fundamental sciences for scientific observations and experiments which can only be met by use of space vehicles such as satellites, space probes, high altitude rockets, etc. In specific cases, the Foundation provides support to study the character and feasibility of experimental equipment suitable for research in outer space, recognizing that research for space exploration as such, and provision of vehicles and their scheduling are essentially an NASA responsibility.
>
> The more basic a research result, the wider is the area of its potential application. For this reason, it is difficult to set down exact criteria for determining whether a particular project has "close" relation to space science. The problem is most apparent in the case of physics research projects, where it is difficult to think of an area of investigation which does *not* have some application to space science or technology (consider, for example, mechanics, nuclear physics, fluid dynamics, plasma physics, low temperature research, and solid state research). Similarly, in the biological and medical sciences programs, difficulties are presented in determining a "close" relationship with space science. The Foundation, however, supports a very substantial program of research in

the biological and medical sciences, much of which will find important application and use in space science.

* * * * *

The National Science Foundation was established as an independent agency in the executive branch by the National Science Foundation Act of 1950. Subsequent revisions to the Foundation's original charter have been made by Presidential Executive orders and legislation. The pertinent portions of the National Science Foundation Act are included here, followed by references to the major changes that have taken place in the Foundation's evolving scientific role.

FUNCTIONS OF THE FOUNDATION

SEC. 3. (a) The Foundation is authorized and directed—

(1) to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences;

(2) to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) for the conduct of such basic scientific research and to appraise the impact of research upon industrial development and upon the general welfare;

(3) at the request of the Secretary of Defense, to initiate and support specific scientific research activities in connection with matters relating to the national defense by making contracts or other arranagements (including grants, loans, and other forms of assistance) for the conduct of such scientific research;

(4) to award, as provided in section 10, scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering, and other sciences;

(5) to foster the interchange of scientific information among scientists in the United States and foreign countries;

(6) to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups;

(7) to establish such special commissions as the Board may from time to time deem necessary for the purposes of this Act; and

(8) to maintain a register of scientific and technical personnel and in other ways provide a central clearinghouse for information covering all scientific and technical personnel in the United States, including its Territories and possessions.

(b) In exercising the authority and discharging the functions referred to in subsection (a) of this section, it shall be one of the objectives of the Foundation to strengthen basic

research and education in the sciences, including independent research by individuals, throughout the United States, including its Territories and possessions, and to avoid undue concentration of such research and education.

* * * * *

[Press release, Mar. 17, 1954]

THE WHITE HOUSE.

The President today issued an Executive Order designed to strengthen the conduct and administration of the scientific research and development programs of the various departments and agencies of the Federal Government.

The order directs the National Science Foundation to make studies of the scientific activities of the Nation and to recommend to the President policies to strengthen the research effort and define the Federal Government's role in it. The Foundation, over a period of time, is expected to become increasingly responsible for providing Federal support for basic research carried on in universities and other nonprofit institutions. Other Federal agencies, however, will continue to carry on basic research which is closely related to their statutory missions.

The Foundation will also study the effects of Federal research support on the Nation's educational institutions and recommend policies and procedures to promote the attainment of the Federal research objectives while safeguarding the strength and independence of the educational institutions.

The order also directs the head of each agency engaged in research to make sure that such research programs reflect urgent needs and are carried on economically and with regard to the efficient use of scientific manpower. In this connection the order provides a new method to facilitate the exchange of scientific equipment and facilities among the Federal agencies so as to avoid buying new equipment or building new facilities when another agency has unused equipment or facilities available.

In connection with his approval of the order, the President made the following statement:

"Science has a vital role in our Nation's security and growth. During the past half-century, it has brought about a vast transformation in industry, in agriculture, in medicine, in transportation, and in communications. Military science has been revolutionized by technological development. The impact of science is increasingly felt in every field of public policy including foreign affairs. All this has been brought about through a combination of vision, initiative, business enterprise, a strong educational system, and the dedicated enthusiasm of the scientific community.

"The responsibilities of the Federal Government toward science have likewise changed greatly. In 1940, the Federal Government spent about one hundred million dollars in supporting research and development. The budget which I have just transmitted to the Congress calls for expenditures for

these purposes in the next fiscal year of over two billion dollars. This is convincing evidence of the important role of science and technology in our national affairs.

"This rapid expansion of Federal responsibility requires prudent administration. More than half of all the investment in the Nation today for scientific research and development is being made by the Federal Government. In large measure, these Federal funds are paid to industry and educational institutions for the conduct of research and development projects. Thus our Federal policies and practices regarding research and development are felt immediately and substantially by industry and our educational institutions.

"More than ninety percent of this Federal support is presently going into applied research and development. This is the practical application of basic knowledge to a variety of products and devices. However, only a small fraction of the Federal funds is being used to stimulate and support the vital basic research which makes possible our practical scientific progress. I believe strongly that this Nation must extend its support of research in basic science.

"While the Executive Order which I have signed today calls upon the National Science Foundation to carry out important responsibilities in regard to scientific research, it is also designed to strengthen the conduct and support of vital research and development in the several agencies where science is important in achieving their assigned missions.

"This order will, for the first time, set in motion important steps leading to a thorough and continuing review of the status of the Federal Government's activities in science, and thus enable the Government, together with industry, higher education, and the scientific community to move forward with assurance toward the achievement of the Nation's goals.

"I expect and believe that this order will clarify the position of the Government toward the support and advancement of science in the Nation, and that it will contribute in a constructive sense to the development of our national policy in this important and critical area."

Administration of Scientific Research by Agencies of the Federal Government

[Executive Order 10521, March 17, 1954, as amended by Executive Order 10807, March 13, 1959]

Whereas the security and welfare of the United States depend increasingly upon the advancement of knowledge in the sciences; and

Whereas useful applications of science to defense, humanitarian, and other purposes in the Nation require a strong foundation in basic scientific knowledge and trained scientific manpower; and

Whereas the administration of Federal scientific research programs affecting institutions of learning must be consistent with the preservation of the strength, vitality, and independence of higher education in the United States; and

Whereas, in order to conserve fiscal and manpower resources, it is necessary that Federal scientific research programs be administered with all practicable efficiency and economy; and

Whereas the National Science Foundation has been established by law for the purpose, among others, of developing and encouraging the pursuit of an appropriate and effective national policy for the promotion of basic research and education in the sciences:

Now, therefore, by virtue of the authority vested in me as President of the United States, it is hereby ordered as follows:

Section 1. The National Science Foundation (hereinafter referred to as the Foundation) shall from time to time recommend to the President policies for the promotion and support of basic research and education in the sciences, including policies with respect to furnishing guidance toward defining the responsibilities of the Federal Government in the conduct and support of basic scientific research.

Sec. 2. The Foundation shall continue to make comprehensive studies and recommendations regarding the Nation's scientific research effort and its resources for scientific activities, including facilities and scientific personnel and its foreseeable scientific needs, with particular attention to the extent of the Federal Government's activities and the resulting effects upon trained scientific personnel. In making such studies, the Foundation shall make full use of existing sources of information and research facilities within the Federal Government.

Sec. 3. The Foundation, in concert with each Federal agency concerned, shall review the basic scientific research programs and activities of the Federal Government in order, among other purposes, to formulate methods for strengthening the administration of such programs and activities by the responsible agencies, and to study areas of basic research where gaps or undesirable overlapping of support may exist, and shall recommend to the heads of agencies concerning the support given to basic research.

Sec. 4. As now or hereafter authorized or permitted by law, the Foundation shall be increasingly responsible for providing support by the Federal Government for general-purpose basic research through contracts and grants. The conduct and support by other Federal agencies of basic research in areas which are closely related to their missions is recognized as important and desirable, especially in response to current national needs, and shall continue.

Sec. 5. The Foundation, in consultation with educational institutions, the heads of Federal agencies, and the Commis-

sioner of Education of the Department of Health, Education, and Welfare, shall study the effects upon educational institutions of Federal policies and administration of contracts and grants for scientific research and development, and shall recommend policies and procedures which will promote the attainment of general national research objectives and realization of the research needs of Federal agencies while safeguarding the strength and independence of the Nation's institutions of learning.

Sec. 6. The head of each Federal agency engaged in scientific research shall make certain that effective executive, organizational, and fiscal practices exist to ensure (a) that the Foundation is consulted on policies concerning the support of basic research, (b) that approved scientific research programs conducted by the agency are reviewed continuously in order to preserve priorities in research efforts and to adjust programs to meet changing conditions without imposing unnecessary added burdens on budgetary and other resources, (c) that applied research and development shall be undertaken with sufficient consideration of the underlying basic research and such other factors as relative urgency, project costs, and availability of manpower and facilities, and (d) that, subject to considerations of security and applicable law, adequate dissemination shall be made within the Federal Government of reports on the nature and progress of research projects as an aid to the efficiency and economy of the overall Federal scientific research program.

Sec. 7. Federal agencies supporting or engaging in scientific research shall, with the assistance of the Foundation, cooperate in an effort to improve the methods of classification and reporting of scientific research projects and activities, subject to the requirements of security information.

Sec. 8. To facilitate the efficient use of scientific research equipment and facilities held by Federal agencies:

(a) the head of each such agency engaged in scientific research shall, to the extent practicable, encourage and facilitate the sharing with other Federal agencies of major equipment and facilities; and

(b) a Federal agency shall procure new major equipment for facilities for scientific research purposes only after taking suitable steps to ascertain that the need cannot be met adequately from existing inventories or facilities of its own or of other agencies.

Sec. 9. The heads of the respective Federal agencies shall make such reports concerning activities within the purview of this order as may be required by the President.

Sec. 10. The National Science Foundation shall provide leadership in the effective coordination of the scientific information activities of the Federal Government with a view to improving the availability and dissemination of scientific information. Federal agencies shall cooperate with and assist the National Science Foundation in the performance of this function, to the extent permitted by law.

3. Bio-Sciences Information Exchange

The Bio-Sciences Information Exchange fills an important gap in the exchange of information in the life sciences by providing information on research which has not reached the publication stage. Designed originally to "prevent unknowing duplication of research support" by the several Federal agencies authorized to expend funds for medical research, it has developed into a unique clearinghouse embracing all of the life sciences. Its growth in scope and volume parallels the increase and extension of Government support of research in the life sciences.

Establishment, policy direction, and functions

The Bio-Sciences Information Exchange was established within the Smithsonian Institution under an "Agreement Concerning the Support and Operation of the Bio-Sciences Information Exchange, September 14, 1953" which defines the responsibilities of the sponsoring agencies and the Smithsonian Institution, and authorizes the BSIE * * * to make routinely available—

(*a*) To cooperating agencies and authorized reviewing bodies the following types of information:

(1) Amounts and sources of support of geographical areas, research institutions, departments, and investigators.

(2) Amounts and sources of support for the broad and specific areas of research listed in the subject index of the BSIE.

(3) Lists of investigators and institutions engaged in special types of research.

(4) Nonconfidential information on policies of granting agencies.

(*b*) To authorize individuals the following types of information:

(1) Lists of investigators and institutions engaged in special types of research.

(2) Magnitude of support in subject or geographical areas without reference to the specific source of support.

(3) Nonconfidential information on the policies of granting agencies.

The original supporting agencies, the Army, the Navy, the Air Force, the National Institutes of Health, the Atomic Energy Commission, and the Veterans' Administration, established the Exchange as a cooperative enterprise in 1950. The National Science Foundation became a supporting agency in 1953, at which time the Exchange was attached administratively to the Smithsonian Institution following its first 3 years under the National Research Council.

A Governing Board, composed of two members from each supporting agency and two members of the Smithsonian Institution, provides policy direction to the Exchange, which in turn operates under the agreement signed by representatives of all supporting agencies and the Smithsonian Institution. Non-Federal granting agencies, both fund raising and private, dispensing funds for research in the life sciences, participate as cooperating but not supporting members, and are not represented on the Governing Board.

Financing

The BSIE is supported through grants and contracts between the supporting agencies and the Smithsonian Institution. Determination of budget requirements is made on an annual basis with all agencies sharing in the costs. No single agency supplies more than 25 percent of the operating costs except with approval of the Board.

Information received and recorded by the BSIE

Information on research supported by granting agencies, both Federal and non-Federal, includes the following:

1. Source of support: Each agency and each part thereof. Example: NIH—each institute and granting program.
2. Amount and duration of support. This is kept in terms of beginning and ending date (in month and year) of each award on each project. Example: For a project supported by a single agency over a span of years, the amounts awarded each year are recorded with the beginning and ending dates of each annual award.
3. The names of the principal investigator and all other professional personnel engaged on the study.
4. The name and address of the institution where the work is being performed. In addition, the college or professional school and department are recorded.
5. The title and a brief summary, prepared by the investigator, of the work being performed.

Information on inservice research, including the following:

1. The names of the principal investigator and all other professional personnel engaged on the study.
2. The name and address of the institution where the work is being performed, including any subdivisions and departments.
3. The title and a brief summary, prepared by the investigator, of the work being performed.

A standard form called the notice of research project is used to register research with the Exchange and is also used in connection with replies to requests. From this form all administrative information and the subject index are recorded on magnetic tape.

All agencies do not register applications, some register only awards. The following numbers of applications and awards were registered during the first 6 months of fiscal year 1960.

Periods	Applications	Awards	Total
July	2,669	5,756	8,425
August	1,363	3,499	4,862
September	1,048	2,969	4,017
October	1,680	1,368	3,048
November	2,361	4,514	6,875
December	736	1,311	2,047
Grand total	9,857	19,417	29,274

In addition, extensions of dates, changes in investigators, withdrawals, etc., account for thousands of updating items monthly.

Information provided by the BSIE

Granting agencies receive the following information:

1. Reports on the support of applicants for grants or contracts. Each report is accompanied by the pertinent notices of research projects. The numbers of such reports prepared during the first 6 months of fiscal year 1960 were as follows:

Periods:	*Reports*
July	309
August	1,284
September	3,016
October	620
November	237
December	3,955
Total	9,421

To fulfill this responsibility the Exchange keeps its records constantly updated.

2. Reports on the distribution of awards prepared in a variety of ways.

In addition, properly constituted committees and survey groups receive information on the extent and variety of work in broad subject fields, and individual investigators receive notices of research projects on current and terminated work on specific topics.

As a valuable byproduct of the fundamental responsibility of the Exchange (to receive information from many different sources and to organize and relate it so as to keep its supporting agencies cognizant of the amounts and sources of support to individual scientists, institutions, and subject fields), a center of information on current research is also being maintained. In this aspect the Exchange does not furnish information on progress or results of research; its purpose is to identify research problems and the investigators working on them. This is accomplished by supplying to scientists, upon specific request, copies of pertinent summaries submitted on the notice of research project form. The potentialities of this service rests ultimately with the research scientist; he provides a description of his work (which he is asked to bring up to date annually), and he uses the clearinghouse for information about other scientists working on problems in his field of interest.

At present there are over 21,000 current research projects registered with the Exchange; the number of projects which are no longer active is much greater. Experience has also shown that terminated projects have a special value, since they are often referred to as a source

of information on negative results and on other data which have not been published.

Although research conducted under extramural funds remains a primary responsibility, the need for information about inservice research was also recognized and the inservice programs of several of the supporting agencies are now registered routinely. There is also an increasing number of researchers who are listing their non-grant-supported research with the Exchange.

The uses of the information have kept pace with its growth in size; the services of the Exchange are utilized by granting agencies for information on amounts and sources of support to individuals, to institutions, and to types of research. Also, committees planning symposiums and surveys of research find it advantageous and effective to use a single source for rapid receipt of information organized to their requirements as to what is being done, by whom, and where. Finally, the individual scientist saves time and effort by knowing who else is working on a problem he is planning to investigate.

4. Federal Council for Science and Technology

[Press release—March 13, 1959]

The White House.

The President today signed an Executive order establishing the new Federal Council for Science and Technology. The Council will promote closer cooperation among Federal agencies in planning their research and development programs, and will recommend ways in which the Federal Government can assist in advancing and strengthening the Nation's scientific effort as a whole.

In establishing the Council, the President said:

> Less than 20 years ago, Federal support of science was about $100 million annually. Today, this annual investment in research and development has grown to over $5 billion, and a large fraction of these Federal funds is spent in laboratories owned and operated by private groups. It is the responsibility of the Federal Government to encourage in every appropriate way the scientific activities of non-Government institutions; but it is apparent from the size of these Federal expenditures that the policies and practices of the Federal Government can exert an immediate and substantial effect on the Nation's private scientific institutions as well as on Government laboratories.
>
> I believe that the new Federal Council for Science and Technology can effectively aid the objective of improving the ways in which the Federal Government uses and supports science. Moreover, the report of my Science Advisory Committee on "Strengthening American Science" also pointed to a number of opportunities for advancing our total national program. I expect the new Council to consider and evaluate these opportunities and to encourage all Government agencies further to increase the quality of their efforts in these fields. By fostering greater cooperation among Federal agencies in planning their research and development programs, by facilitating the resolution of common problems, and by reviewing the impact of government policies on the programs of nongovernmental institutions, the Council should be able to contribute greatly to the development and advancement of our national programs in these important and critical areas.

The President has asked Dr. James R. Killian, Jr., his Special Assistant for Science and Technology, to serve as Chairman of the Council. Its membership will include representatives of the departments and agencies of the Government which play a major part in this field. This includes Defense, Interior, Agriculture, Commerce, Health, Education, and Welfare, and the Director of the National

Science Foundation, the Administrator of the National Aeronautics and Space Administration, and the Chairman or another member of the Atomic Energy Commission. The Chairman may invite other persons to attend meetings when appropriate and representatives of the Secretary of State and the Director of the Bureau of the Budget will attend as observers. Attention has been called to the fact that the task of further strengthening U.S. science is so broad that government, industry, universities, foundations, and individuals all have essential roles to play. For the future growth and strength of American science will depend upon the efforts of all of these parts of our national community if we are to rise to the demands of our times.

To assure the Council the benefit of continuing advice from the career scientists in the Federal service, the order provides for a standing committee of the Council composed of scientist-administrators principally responsible for the direction of research and development programs in Federal agencies. Such a committee may include representatives from other agencies having important scientific and technical activities and not named as members of the Council. The standing committee will undertake studies for and make reports to the Council, and will be called upon to provide a continuing source of recommendations to the Council. In this way an organized means will be established for bringing to the President the advice and recommendations of both the policy officials and the career scientists in the major research and development agencies. Executive Order 9912 which established the Interdepartmental Committee on Scientific Research and Development is revoked by the new Executive order.

The President has also directed Federal agencies to cooperate with and assist the National Science Foundation in its role of providing leadership for improving the availability and dissemination of scientific information.

EXECUTIVE ORDER 10807 ESTABLISHING FEDERAL COUNCIL FOR SCIENCE AND TECHNOLOGY

Whereas science and technology are essential resources for the security and welfare of the United States; and

Whereas Federal programs in science and technology will advance our security, health, and economic welfare and the quality of education in the United States; and

Whereas closer cooperation among Federal agencies will facilitate the resolution of common problems in science and technology, promote a greater measure of coordination, and otherwise improve the planning and management of Federal programs in these fields:

Now, therefore, by virtue of the authority vested in me as President of the United States, it is hereby ordered as follows:

Section 1. *Establishment of Council.* (a) There is hereby established the Federal Council for Science and Technology (hereinafter referred to as the Council).

(b) The Council shall be composed of the following-designated members: (1) the Special Assistant to the President for Science and Technology, (2) one representative of each of the following-named

departments, who shall be designated by the Secretary of the Department concerned and shall be an official of the Department of policy rank: the Departments of Defense, the Interior, Agriculture, Commerce, and Health, Education, and Welfare, (3) the Director of the National Science Foundation, (4) the Administrator of the National Aeronautics and Space Administration, and (5) a representative of the Atomic Energy Commission, who shall be the Chairman of the Commission or another member of the Commission designated by the Chairman. A representative of the Secretary of State designated by the Secretary and a representative of the Director of the Bureau of the Budget designated by the Director may attend meetings of the Council as observers.

(c) The Chairman of the Council (hereinafter referred to as the Chairman) shall be designated by the President from time to time from among the members thereof. The Chairman may make provision for another member of the Council, with the consent of such member, to act temporarily as Chairman.

(d) The Chairman (1) may request the head of any Federal agency not named in section 2(b) of this order to designate a representative to participate in meetings or parts of meetings of the Council concerned with matters of substantial interest to the agency, and (2) may invite other persons to attend meetings of the Council.

(e) The Council shall meet at the call of the Chairman.

Section 2. *Functions of Council.* (a) The Council shall consider problems and developments in the fields of science and technology and related activities affecting more than one Federal agency or concerning the over-all advancement of the Nation's science and technology, and shall recommend policies and other measures (1) to provide more effective planning and administration of Federal scientific and technological programs, (2) to identify research needs including areas of research requiring additional emphasis, (3) to achieve more effective utilization of the scientific and technological resources and facilities of Federal agencies, including the elimination of unnecessary duplication, and (4) to further international cooperation in science and technology. In developing such policies and measures the Council, after consulting, when considered appropriate by the Chairman, the National Academy of Sciences, the President's Science Advisory Committee, and other organizations, shall consider (i) the effects of Federal research and development policies and programs on non-Federal programs and institutions, (ii) long-range program plans designed to meet the scientific and technological needs of the Federal Government, including manpower and capital requirements, and (iii) the effects of non-Federal programs in science and technology upon Federal research and development policies and programs.

(b) The Council shall consider and recommend measures for the effective implementation of Federal policies concerning the administration and conduct of Federal programs in science and technology.

(c) The Council shall perform such other related duties as shall be assigned, consonant with law, by the President or by the Chairman.

(d) The Chairman shall, from time to time, submit to the President such of the Council's recommendations or reports as require the attention of the President by reason of their importance or character.

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APPENDIXES

1. "FROM AVIATION MEDICINE TO SPACE MEDICINE"

DR. HUBERTUS STRUGHOLD*

(From: Air University Quarterly Review, Summer 1958, Vol. X, No. 2)

THE potentialities of human flight are undergoing a radical change. This change has been brought about by the rapid and successful developments in rocketry during and since World War II.

The rocket is a self-contained propulsion device—the only kind known that is independent of an external medium both dynamically and chemically. Dynamically, to attain propulsion it does not require an atmospheric medium to "push against" but rather "pushes against itself." Chemically, it carries its own oxygen or other forms of oxidizers for fuel combustion, in contrast to the jet engine which makes use of atmospheric oxygen in this respect. In case nuclear energy is used, oxygen is not required at all. Furthermore, the powerful thrust of a rocket exceeds by far all other propulsion methods.

These unique features enable a rocket to reach beyond the regions of the atmosphere and operate in space. In fact it is even more efficient in a vacuum. Its natural habitat, therefore, is outside the atmosphere. With regard to its preferred environment, the rocket is a *spacecraft*. In contrast propeller planes and jet planes while "wing supported" and "air supported" can operate only inside the atmosphere within a certain density range. Environmentally they are both aircraft, but the jet is transitional to the rocket.

The altitude ceiling for air-supported craft and air-breathing engines is maximally around 20 miles or about 30 kilometers, the limiting factor being the density of the atmosphere. In contrast the rocket has practically no limitation in altitude. Its vertical operational range is determined exclusively by the thrust. In the realm of rocket flight, therefore, the concept of height above the earth's surface blends into that of "distance" from the earth. The rocket alone has really conquered the third or vertical dimension in flight. It has opened a new frontier to the flyer: the "vertical frontier."

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* Dr. Hubertus Strughold, Ph.D. University of Muenster, M.D. University of Wuerzburg, is Chief, Department of Space Medicine, School of Aviation Medicine, USAF. A pioneer in aviation medicine, Dr. Strughold performed research in this country in 1928-29 as a Fellow of the Rockefeller Foundation. In 1935 he became director of the Aeromedical Research Institute in Berlin, associate professor of physiology at the University of Berlin and by 1945 was a colonel in the German Medical Corps. After the war he was appointed Director of the Physiological Institute, University of Heidelberg. In 1947 he joined the School of Aviation Medicine, USAF. Longtime author and lecturer on physiology, aviation medicine, and space medicine, Dr. Strughold has written a book describing Mars, *The Green and Red Planet*, coauthored *Principles of Aviation Medicine* and an atlas on aviation medicine.

The process of motion along this vertical frontier also reveals the novelty of things to come. Flights in conventional planes are accomplished by the steadily acting power of propulsion. Great variations in the g forces generally do not occur; motion, therefore, is more or less uniform. It lies in the nature of rocket propulsion that fuel expenditure takes place during the first few minutes only, followed by a period of coasting without power or of flight by inertia until the vehicle re-enters the atmosphere. At the beginning and end of rocket flight we encounter high accelerations and decelerations, respectively, resulting in exposure to multiples of g. During the period of coasting the vehicle follows the laws of ballistics and even those of celestial mechanics as formulated in the three laws of planetary motion by Johannes Kepler. The latter means that the vehicle itself behaves like a celestial body following a path which exhibits the characteristics of an orbit (circle, ellipse, and parabola). In such orbits the force of the earth's gravitation is balanced by inertial forces with the result that both craft and passengers become weightless. Thus an environmental factor—weight—which is present everywhere and at all times on the ground and in conventional flights, is eliminated.

The velocities observed in space flight may approach those of meteors. They exceed by far the speeds attainable in atmospheric flights by jet-propelled planes, which may reach about three times the speed of sound. In rocket flight beyond the atmosphere this speed unit expressed in mach numbers is irrelevant. The velocities attainable by rocket propulsion make conceivable an approach to other celestial bodies with a strange environment and perhaps with living organisms. The telescope has brought these celestial bodies closer to us optically, but the rocket has the potentialities of bringing us closer to them physically.

To summarize: First, the environment in rocket-powered flight has the properties not of the atmosphere but largely or completely those of free space. Second, the rocket itself with regard to its motion behaves like a celestial body. And third, other celestial bodies may soon be reachable from the earth. These three facts indicate that we have entered a novel, revolutionary phase in the development of flight, in fact, in the history of man. We are at the *threshold of human space flight*.

organizing space medicine in the Air Force

The near advent of a capability for manned space flight was of extreme importance to the United States Air Force. In anticipation of the medical implications involved in a new branch of technology, now named space technology, Major General Harry G. Armstrong created in February 1949 at Air University's School of Aviation Medicine, Randolph Air Force Base, Texas, a special department for the study of the medical problems encountered in flights beyond the atmosphere. It was named the Department of Space Medicine, with the writer as its chief and Dr. Heinz Haber as astrophysicist.

The fact that this department was founded at an aviation medical insti-

tution indicates that space medicine is actually an extension of aviation medicine. It developed from the latter partly in distinctly recognizable steps toward medical space research and partly in an invisible way in experiments which were carried out to meet the requirements of high-performance aircraft but which can today be regarded as belonging, at least to some extent, to the realm of space medicine. These researchers[8 5 27 51] pioneered along the borderlines of a field which came officially into being several years after World War II.

At about the same time the Department of Space medicine was founded, preparations for animal studies in rockets began under Brigadier General Edward J. Kendricks and later Colonel Robert H. Blount at the Aero Medical Laboratory at Wright-Patterson Air Force Base, Ohio. The Aero Medical Laboratory had suitable facilities for this type of work at Holloman Air Force Base, New Mexico. In 1952 the research activity at Holloman was made an independent Aero Medical Field Laboratory under Lt. Colonel John P. Stapp with a Space Biology Branch under Major David G. Simons.

developments toward space medicine

In the following an attempt is made to describe the historical development of space medicine based on those studies and events which show distinctly the trends or steps toward space flight, the exploration of space, and travel to other celestial bodies. This article does not claim completeness in detail but rather will give an over-all picture of the transition from aviation medicine to space medicine—where, when, and in what scientific areas it took place. More details are available in references 22, 23, 31, and 44.

But it should be noted that transition does not mean replacement. Aviation or atmospheric flight will always play the dominant role in human flight; and aviation medicine or aeromedical studies will always be required for the health and efficiency of the crew and safety of the passengers, especially in these days of increasing air traffic. Space flight will probably always have the characteristics of an operation or an expedition.

As in any pioneer field, general theoretical space medical considerations preceded the specific experimental approach. Two things had to be determined: first, the actual differences between atmospheric flight and space flight, and second, the height above the earth's surface beyond which atmospheric flight becomes space flight. The answers were found in an analysis of the atmospheric functions for human flight: in the concept of the "functional borders" between atmosphere and space,[9 42 52] and in the concept of atmospheric "space equivalence."[46] On the basis of these theoretical considerations, it was recognized that space conditions actually begin as low as 12 miles with regard to certain environmental factors and that practically all space conditions are met above 120 miles. But planes as well as balloons had already penetrated deep into the region of partial space equivalence. Consequently "space-equivalent flight" became the technical term for all flights above 12 miles.

Special experimental research, preceded or accompanied by theoretical analysis, was concentrated upon three major areas:

—the g pattern which included a large range from zero g to multiples of g;

—the study of the biological effect of cosmic rays; and

—the development of a closed ecological system as represented by a cabin to be used in space or even as low as 70,000 to 80,000 feet.

Weightlessness. Considerations of tolerance to zerogravity or weightlessness date back to immediately after World War II. But even during the war occasional observations were made in this respect. In October 1946 a seminar was held at the Aeromedical Center in Heidelberg to discuss "Man under Weightless Conditions." The content of this seminar was published in 1950.[13] At about the same time similar discussions took place at Wright-Patterson Air Force Base.[34]

A solid theoretical basis was laid in a paper entitled "Possible Methods of Producing the Gravity-Free State for Medical Research" prepared by scientists at the USAF School of Aviation Medicine in 1951.[17 19] Finally actual animal experiments were carried out in rockets by the Wright-Patterson Aero Medical Laboratory at its field facilities at Holloman Air Force Base in 1952.[24] An altitude of 36 miles was reached in these rocket flights, and the state of weightlessness lasted about 3 minutes.

Soon jet planes were used to study human tolerance to weightlessness at Wright-Patterson Air Force Base[4] and by the School of Aviation Medicine at Randolph Air Force Base,[15 16] as well as by the Aero Medical Field Laboratory at Holloman Air Force Base.[36] The number of parabolic flight maneuvers flown up to the present time at Randolph Field alone is well over four thousand. The duration of the state of weightlessness attained during these parabolic arcs is maximally a little less than one minute. For such a short period we now have a pretty good idea of zero g tolerance.

These experiments carried out in jet planes represent historically the first phase of the study of human tolerance to weightlessness. The next phase will be experiments in rocket-powered craft of the X-15 type, in Dynasoar, and eventually in vertical rocket flight and orbital flight. It may be added that in 1956 comparative studies of subgravity conditions in swimming pools were carried out at the School of Aviation Medicine and at the Aero Medical Field Laboratory.

Multiple g forces. The study of increased g forces dates as far back as the middle thirties. They were carried out on large centrifuges at Wright-Patterson Air Force Base, at the Mayo Clinic,[55] and more recently at the Navy's Medical Laboratory at Johnsville, Pennsylvania. These experiments were required because of the high accelerations during certain maneuvers in atmospheric flight, the necessity of testing anti-g suits, etc. In atmospheric flight maneuvers the g forces seldom exceed 4 g.

During the launching period of a rocket, however, peaks up to 9 g may be experienced, and during atmospheric re-entry even higher values. The g pattern expected during launching was simulated on a human centrifuge in 1955.[32] Valuable results about the tolerability of extremely high g have been

obtained by means of experiments on a sled at Holloman Air Force Base since 1950.[40 41] Because of these many experiments carried out through different means, the physiological effects of increased g are basically well understood today.

Cosmic rays. The problem of biological effects of cosmic rays has been approached theoretically and experimentally. The Navy's School of Aviation Medicine at Pensacola, Florida, concentrated on the theoretical biological evaluation of the cosmic ray data obtained in rockets and started with these studies as early as 1950.[33] The Space Biology Branch at Holloman Air Force Base undertook experimental studies in 1951, partly in cooperation with the School of Aviation Medicine at Randolph Air Force Base. The vehicles used in these experiments were rockets and ultra-high-altitude balloons. So far only minor effects of cosmic rays on mice (grey hairs) have been detected.[35 36] The ultimate research vehicle will be a returnable biosatellite which permits longer exposure times and the penetration of high-intensity radiation regions, such as have been discovered recently by the Explorer satellites.

The sealed space cabin. One of the most important and vital tasks of space medicine is to keep a man alive in an environment which is distinguished by the absence of an atmosphere. This has to be achieved by the development of a sealed cabin which carries its own atmosphere for the crew.

Such devices have been developed in the form of sealed capsules designed for animal experiments and manned flight in high-altitude balloons at the Space Biology Branch at Holloman.[37] These efforts made possible the record balloon flight of Lt. Colonel David G. Simons to 102,000 feet in August 1957. The Department of Space Medicine developed an experimental sealed chamber at Randolph Air Force Base for laboratory studies,[48] a so-called space cabin simulator, in which in 1957 a 24-hour experiment and early in 1958 a 7-day experiment were successfully performed.

For experiments or flights of days or weeks duration, physical and chemical means are probably the sole method for the regeneration of the cabin's air.[11 12 26] For longer periods of time, biological gas exchangers may be more efficient. To cope with this eventual situation, the School of Aviation Medicine sponsored a project to use plants for the regeneration of the air. These studies were started at the Department of Zoology at the University of Texas in 1954[29] and in a more applied form at the School of Aviation Medicine.[14] In these biological studies in a closed ecological system the recycling of fluid and semisolid body wastes for reutilization has recently been included.

Apart from these main research areas other problems of space medicine have been attacked, such as the physiology of the day-night cycle, psychology of isolation, nutrition, toxicity of rocket fuel, selection of crew,[7] bailout at very high altitudes, etc.[18]

development of astrobiology

Closely related to space medicine is a scientific field which deals with the ecological conditions on other planets and with the question of life on

these celestial bodies. This field has been called "planetary ecology" or "astrobiology." It is a field not only of interest to the astronaut but also of general human interest. The roots of this study go back to 1877 when G. V. Schiaparelli, astronomer in Milan, Italy, discovered strange features on the surface of Mars which he called "canali." This started the discussion of life on other planets which around 1910 reached its first climax in the publications of Percival Lowell, founder and director of the Astronomical Observatory in Flagstaff, Arizona.*

The recent rapid progress made in space technology and space medicine has had a catalytic effect upon the occupation with astrobiological questions, as is evidenced by a great number of new publications. In contrast to former times when such publications were written exclusively by astronomers, now biologists and medical doctors have entered the field. This is very desirable because astrobiology, as the term indicates, is actually a field common to astronomy and astrophysics on one side, and biology and medicine on the other. Astrobiology started with the question of the possibility of indigenous life on other celestial bodies. This is a matter of general biology. The prospects offered by the construction of space vehicles to approach other celestial bodies and eventually to land there have raised the question of what conditions an astronaut would find there with regard to himself or, in other words, from the standpoint of human physiology. Both aspects have been discussed in recent years in many publications and meetings.

As far as the Air Force is concerned, the School of Aviation Medicine had a project as early as 1947 to study the ecological conditions on other planets. As a result of this project various publications appeared concerning the possibility of life on Mars, such as *The Green and Red Planet.*[43] [45] The marriage between astronomy and biology led to new concepts such as that of the "ecosphere" in the solar system.[47] The ecosphere represents a zone in a certain distance range from the sun in which the ecological conditions in space and those on the planets are favorable to space operations and to life. This concept was adopted by a Polish astronomer in 1957 for consideration of the stars found in space up to 17 light years distance from the sun, as he reported to the Congress of the International Astronautical Federation in Barcelona in 1957.

At this point it may be noted that in 1953 in Russia two books were published under the titles *Astrobiology* and *Astrobotany* by G. Tikhof. In these books attention is concentrated upon the optical properties of the

*[The Italian "canali," by which Schiaparelli meant "channels," designated the network of dark lines resembling according to Schiaparelli "the finest thread of spider's web drawn across the disk" of Mars which he and a number of other competent observers have observed at the dimmest limit of vision. Other competent observers have never seen the "canali," and the markings have not shown on any photographs clearly enough for general acceptance. Professor Lowell, who recorded many successful observations, readily accepted the suggestion the Italian word had in English and was so much impressed by the geometric regularity of the network he himself saw that he proclaimed it an artificial irrigation project, such as might be made visible by bordering vegetation. Many American astronomers have followed Lowell in accepting at least the existence of the markings as real surface features of some kind. Opinion has been advanced that the lines may be cracks in the Martian surface, rays like those on the Moon, or perhaps the vagaries of surface detail transmuted by the observer's straining vision into lines. Concerning life on Mars, most areologists accept the existence of broad areas of vegetation, observed as dark green regions between the polar frost caps, in contrast with the red desert that covers five eighths of the surface. This vegetation is considered to be a primitive type of moss or lichen. Ed.]

green areas on Mars. Recently a book entitled *Astrobiologia*, by F. A. Pereira, appeared in Brazil. Apart from his own contributions the author reviews the "North American School of Thinking" and that of the "Soviet School."

An event which may be considered of historical importance was a symposium on "Problems Common to Astronomy and Biology" held at a joint meeting of the Astronomical Society of the Pacific and the International Mars Committee on 15 June 1957 at Flagstaff, Arizona.[80 84] It was the first symposium of its kind. Mars was the chief topic of the discussions, and the speakers based their reports on the latest spectographic observations, advanced ecological considerations, and space medical achievements. Physiological optics and the use of balloons as astronomical observatories, which require sealed gondolas as developed in space medicine,[89] were among the topics.

The development of transatmospheric astronomical observatories attached to ultra-high-altitude balloons or borne in satellites will mean an important mark in the history of astronomy and astrobiology. As for the latter, the ultimate goal will be an actual approach to other celestial bodies by means of manned space vehicles. We can, of course, simulate to a high degree the environmental conditions on Mars in a chamber and examine the behavior of terrestrial microorganisms. Studies of this kind in a "Mars chamber" were initiated in 1956 in the SAM Department of Microbiology at Randolph AFB.[25] This experimental approach is interesting not only from the standpoint of astrobiology but also of general biology and philosophy.

milestones in space medicine and astrobiology

This review of the history of space medicine and astrobiology would not be complete if pertinent meetings and organizations were not included. In November 1948 Major General Harry G. Armstrong held a panel discussion on "The Medical Problems in Space Travel" in which members of the SAM Department of Space Medicine presented papers and six noted scientists from universities and Armed Services institutions participated as discussion speakers.[1] In 1950 a panel discussion on "Space Medicine" was organized by Drs. A. C. Ivy and John P. Marbarger at the University of Illinois.[28] This was the first space medicine meeting which had as one of its participants a rocket pioneer: Wernher von Braun. The others were H. G. Armstrong,[2] H. Haber, Konrad Buettner,[8] Paul Campbell,[10] and the writer.

An important step in the exchange of knowledge on space flight between scientists was the first international symposium on "The Physics and Medicine of the Upper Atmosphere." Forty-four speakers from various countries appeared on the program which was held in San Antonio, Texas, in November 1951. This symposium was organized by Major General Otis O. Benson, Jr., Commandant of the School of Aviation Medicine at Randolph AFB, and Dr. Clayton S. White of the Lovelace Foundation, Albuquerque, New Mexico. A considerable portion of the material presented was devoted to space, space flight, and the medical problems involved. The papers were published in book form.[83]

In 1950 an organization was created for the specific purpose of promoting

space medicine: the Space Medicine Branch of the Aero Medical Association. Organized in Chicago with 20 charter members, it is now ten times its original size. Since 1952 this group has regularly held a panel discussion of the latest developments in this field at the annual meetings of the Aero Medical Association. As a rule these papers are published in the *Journal of Aviation Medicine* (Dr. Robert J. Benford, editor), which has played a pioneer role in the distribution of advanced ideas. Other publications concerning the problems and development of space medicine are listed in the bibliography.[7 20 21 30]

Since 1952 space medical papers also began to appear on the programs of technological societies such as the American Rocket Society, the Institute of Aeromedical Sciences, and the American Astronautical Society. At the annual meeting of the American Rocket Society in Chicago in 1955, for instance, the first paper on the medical problems in satellite flight was given.[49] A human-factors panel was also included in the program of the first Symposium on Astronautics, held in San Diego, California, in March 1957. It was organized by the Consolidated Vultee Aircraft Corporation of San Diego (a division of General Dynamics Corporation) and was sponsored by the Office of Scientific Research of the Air Force, Washington, D. C.

In 1954 space medicine entered the international scene at the annual meeting of the International Astronautical Federation.[46] This organization, founded in 1952, now comprises about twenty-five national member organizations. Actually for several years any meeting dealing with the problems of space flight has been considered incomplete if it did not have space medical topics on its program.

The historical development of space medicine is also reflected in the field of education. For many years courses in aviation medicine for flight surgeons have been held at the School of Aviation Medicine at Randolph AFB, first in the form of primary courses and later also in the form of advanced courses, refresher courses, and review courses. For more than five years space medical and astrobiological topics have been included in these curricula in order to familiarize the medical students and physicians with problems of the future. Space medicine was also found on the program of two lecture series: one on satellites offered by the Massachusetts Institute of Technology in 1956, and the other on space technology given at the University of California in the spring of 1958.

There is another point worth mentioning. On 5 May 1958 two representatives of space medicine appeared before the special House Select Committee on Astronautics and Space Exploration in Washington, D. C., to testify about the medical aspects and prospects of space flight. Apparently these were considered important for the future military and civilian organization of the national efforts in astronautics. Furthermore the recent creation of a "Man in Space" committee of Air Research and Development Command under the direction of Brig. Gen. Don D. Flickinger reflects the increasing role of space medicine in astronautics. And the medical research institutions of the Air Force are expanding their facilities and programs in close cooperation with its Ballistic Missile Division.

the renaissance in aero medical research

After World War II it was generally believed that the essential problems involved in human flight had been solved and that medical research was only required to fill some minor gaps. Aviation medicine was considered a matter of routine. But the rocket with its extra-atmospheric capabilities changed this belief, gradually but radically, and we could observe a renaissance in medical and biological research and a distinct movement toward problems related to space. The appearance of artificial satellites in the sky gave this trend a powerful boost. Beyond that it also implied a retroactive justification for the necessity—formerly not generally recognized—of the presatellite pioneer studies, in which the medical institutions of the U.S. Air Force played an early and leading role.

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2. "IMPACT OF SPACE EXPLORATION ON BIOLOGY AND MEDICINE"

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Space exploration offers an unparalleled opportunity for the productive integration of the physical and biological sciences directed toward expansion of our knowledge of the universe. Means of improving human tolerance of the expected combined stresses involved in space flight and provision of adequate life-support systems will be necessary to allow man to lend his unique capabilities to accomplishment of the tasks ahead. New knowledge of extraterrestrial environmental effects on all forms of life will result from studies of comparative biology on the broadest scale and will undoubtedly lead to further understanding of the fundamental laws of nature.

Basic human drives for pioneering and conquest can find acceptable expression in extraterrestrial exploration. It is unmistakably clear that our civilization cannot survive a thermonuclear conflict. The expression of aggressive drives in war has repeatedly supplied an impetus for unusual increments in the growth of the arts and sciences. A historical review of intellectual progress and concomitant technological advance gives reason to expect that expanded knowledge of the universe will produce an unprecedented burst of creative activity in biology and medicine as well as in the physical sciences and engineering.

ROLE OF MAN IN SPACE

Only with the advent of high-altitude high-speed operations within the past two decades has man's role in flight become the subject of intensive study in military aviation medicine, resulting in special adaptation of aircraft and equipment to the pilot. These developments have also brought to the fore the necessity for more discriminating selection of highly intelligent, inherently capable persons for extensive training prior to being given control of intricately designed high-powered vehicles.

At the threshold of the Space Age, questions related to man's participation in space flight and exploration have already assumed significant proportions. Suggestions have been made that reveal doubt in some quarters as to the propriety and ultimate usefuless of man's being

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Read in the Symposium on Medical Problems in the Jet and Space Age before the section on military medicine at the108th annual meeting of the American Medical Association, Atlantic City, June 9, 1959.

propelled into outer space. From some of the same sources the space effort, in general, has been regarded as no more than large-scale participation in an international pyrotechnic display involving sizable sums of the taxpayer's money. The scientific, political, economic, and sociological implications of such statements are unfounded. My remarks are directed to the scientific aspects of space exploration as they relate to biology and medicine.

Initial serious interest in man's role in space has been concerned with the utilization of his unique characteristics which allow him to absorb a wide variety of observations, to process this data, to store it as memory, or to use it to exercise judgment in decisionmaking in a way that could not conceivably be done by any manmade device. Such human qualities as persistence and resourcefulness as well as the relative reliability of complex human systems further indicate the need for man's inclusion in the operational aspects of space flight and exploration.

Research.—Research and development designed to comply with the requirements of manned space flight are now in progress. Military aviation medical personnel are making a major contribution in this area. Their knowledge and experience, gained over the last 20 years, provide a substantial base on which to build for the future.

The immediate needs of space flight are for conquest by man, within the limits of his tolerance, of the stresses of acceleration, vibration, temperature, weightlessness, and impact during the launching, flight, and reentry phases. Life-support systems, insuring survival by maintaining the vehicle environment within physiological limits as to pressure, oxygen supply, humidity, carbon dioxide concentration, and waste removal, are essential. Means of escape in case of impending disaster must be provided. Instrumentation allowing for recording and telemetry of data concerning the function of man and these systems in flight are being further developed. These are some of the prerequisites for determining man's capability of performance which will make it possible for him to lend his unusual talents to the problems at hand. These factors must be projected into the near future when larger payloads and flights of longer duration are feasible. Regenerative systems for support of life which use solar energy to provide fluid, food, and gaseous requirements will then be necessary. Radiation hazards must be further delineated and overcome. Means for management of possible meteorite damage and arrangements for in-flight maintenance of equipment over periods lasting weeks or months, or more, must be developed.

Man's nervous system is the key to his usefulness in the space setting confronting us. With the present emphasis on survival, no vital system, including the heart, circulation, or respiratory mechanism, has been overlooked, but relatively little effort has been made to assess more than the most fundamental life-supporting functions of the brain. The role of the nervous system in the rapid adaptation of the body to the internal and external environment has been established. Longer term adjustments involve hormonal influences which are also under neural control. The physiological concomitants of more complex levels of behavior and performance are little understood. One of several approaches to this problem involves intensified study of the nature of the varied input from sensory receptors.

Weightlessness and other aspects of sensory deprivation have special pertinence in anticipation of manned space flight. More information about the integration and elaboration of the afferent input as it modifies the neural substrate of abstract thought, learning, memory, and emotion is urgently needed. Perceptions are likely to be altered by long-term application of unusual forces on the body sensors, as well as by isolation, fatigue, emotional reactions, and long-duration modifications of cyclic light-dark, sleep-activity, and temperature rhythms. Study of animals and man subjected to real or simulated space environmental conditions offers a unique opportunity to gain fundamental information relating to consciousness, orientation, mentation, emotional reactions, and motor coordination.

INTEGRATION OF THE SCIENCES

A number of new problems of great complexity and interdependence relating to the fields of biology and medicine arise in anticipation of manned space flight and exploration. An unparalleled opportunity for productive integration of the physical sciences, engineering, and the biological sciences is presented and must be comprehensively exploited to produce the desired results. Such integration has been notably difficult to accomplish in the past. The traditional organization of the biological sciences includes: biophysics, biochemistry, physiology, and psychology. Reorganization of this as well as of the physical science and engineering disciplines, in vertical fashion, to be applied to the problems to be studied, will provide the best opportunity for bringing each discipline to bear on the major areas under investigation. Restriction of effort to immediate problems such as acceleration and other forms of stress, radiation effects, and life-support systems would not satisfactorily provide the scope or flexibility necessary for meeting the requirements of the future. Studies from a molecular to an intact organism level, where appropriate, with use of an interdisciplinary approach, are likely to be most productive.

Coordinated efforts in "bioengineering" are now in progress which are concerned with development of a suitable space vehicle environment and other life-support systems consonant with present and anticipated payload capabilities. The limits of tolerance for various physiological stresses and means of adaptation to remain within these boundaries are being determined on centrifuges, in altitude chambers, and by other flight-simulating devices. In this process, a number of technological advances related to designing vehicles to fit men and training men to use them are being accomplished.

The broad application of biophysics is relevant not only to problems of radiation and physiological instrumentation but also to the cardiopulmonary aspects of acceleration and weightlessness. Long-term results of alterations in pressure, gas exchange, humidity, and temperature are worthy of consideration. Investigations of more extensive use of computers for the processing of biological data are appropriate.

Metabolic studies are concerned with cellular division, nutritional requirements, and utilization of energy of a variety of organisms, including man. Chemical and photosynthetic processes are expected to provide regenerative systems to sustain life over long periods of time

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in a closed ecologic system. These closed systems introduce special consideration of intoxicants and contaminants which could be injurious to living organisms. The possible uses of controlled hypothermia are being explored with regard to reduction of metabolic requirements for food and fluid, as well as protection from various stresses, including those in the psychological sphere.

Studies of extraterrestrial environments and their effects on biological adaptation and genetics are of particular interest. Botanical and zoological investigations from a microbiological level to man have pertinence to the exploitation of an entirely new dimension for the observation of biological effects.

Results.—It is not part of scientific investigation to predict the specific utility of the results. However, there is no reasonable doubt that space exploration offers a new vantage point for observation of the effects of environmental factors on all forms of life, which will provide numerous important applications of a practical nature relative to biology and medicine. Absence of gravitational force, extreme alterations in remote atmospheric composition and pressure, radiation, and other energy fields affect organisms of all degrees of complexity, including man. Development of means of measuring and surmounting certain deleterious influences will be forthcoming, which will probably be applicable to many problems we now face on earth. The unfamiliar features of this unexplored environment can be expected to serve as tools for revealing the nature of many hitherto unexplained biological phenomena. Ultimately, it is likely that extraterrestrial living organisms will be discovered as well as physical and biological resources to support life as we know it.

More comprehensive knowledge of the environment in space, on the Moon, and on planets undoubtedly will have a profound influence on man and other forms of life on earth. The horizon, expanded to include progressively more of the universe, can be expected to provide intense stimulation with resultant significant advances in biology and medicine.

3. "PSYCHIATRIC EVALUATION OF CANDIDATES FOR SPACE FLIGHT"[1]

(A Paper by George E. Ruff, Captain, USAF (MC) and Edwin Z. Levy, Captain, USAF (MC), Stress and Fatigue Section, Biophysics Branch, Aero Medical Laboratory, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio)

The high levels of stress expected in space flight require careful screening of potential pilots by psychological and physiological techniques. Since emotional demands may be severe, special emphasis must be placed on psychiatric evaluation of each candidate for a space mission.

The selection process begins with a detailed analysis of both the pilot's duties and the conditions under which he will carry them out. As long as we have had no direct experience with space flight, some aspects of this analysis will necessarily be speculative. We must thus rely heavily on knowledge of behavior during stress situations in the past. As a result, data from military operations, survival experiences, and laboratory experiments have guided the choice of men for space missions now being planned.

Although striking exceptions are seen, the individuals who have done best under difficult circumstances in the past have been mature and emotionally stable. They have usually been able to harmonize internal needs with external reality in an effective manner. When subjected to stress, anxiety has not reached high enough levels to paralyze their activity.

After the requirements of the mission and the qualifications of the individual best suited to accomplish it have been decided, it is necessary to select measures for determining who has the most of each desirable characteristic and the least of each undesirable characteristic. This can be done by using interviews and projective tests to give an intensive picture of each individual. Objective tests supplement the personality evaluation and measure intellectual functions, aptitudes, and achievements. After examination of the background data, interview material, and tests results, clinical judgment is used to decide which men are psychologically best qualified for the assignment.

[1] For presentation to 115th annual meeting, the American Psychiatric Association, Philadelphia, Pa., Apr. 29, 1959.

As firsthand knowledge of space flight increases, these procedures must be reexamined. When enough data have accumulated, predictions can be checked against performance criteria. Methods which predicted accurately will be retained and improved. Those with little value will be discarded. New measures can be added on the basis of increasing experience. Once correlation between psychological variables and the quality of performance have been determined, the accuracy of future selection programs should be raised.

A clinical approach of this type was used in selecting pilots for the first U.S. manned satellite experiment—NASA's Project Mercury. The objective was to choose men for a 2-year training program, followed by a series of ballistic and orbital flights. The pilot's duties will consist largely of reading instruments and recording observations. However, he will retain certain decision-making functions, and will be required to adapt to changing conditions as circumstances may demand.

By combining data on the nature of this mission with information on behavior during other stressful operations, the following general requirements were established:

(1) Candidates should have a high level of general intelligence, with abilities to interpret instruments, perceive mathematical relationships, and maintain spatial orientation.

(2) There should be sufficient evidence of drive and creativity to insure positive contributions to the development of the vehicle and other aspects of the project as a whole.

(3) Relative freedom from conflict and anxiety is desirable. Exaggerated and stereotyped defenses should be avoided.

(4) Candidates should not be overly dependent on others for the satisfaction of their needs. At the same time, they must be able to accept dependence on others when required for the success of the mission. They must be able to tolerate either close associations or extreme isolation.

(5) The pilot should be able to function when out of familiar surroundings and when usual patterns of behavior are impossible.

(6) Candidates must show evidence of ability to respond predictably to foreseeable situations, without losing the capacity to adapt flexibly to circumstances which cannot be foreseen.

(7) Motivation should depend primarily on interest in the mission rather than on exaggerated needs for personal accomplishment. Self-destructive wishes and attempts to compensate for identity problems or feelings of inadequacy are undesirable.

(8) There should be no evidence of impulsivity. The pilot must act when action is appropriate, but refrain from action when inactivity is appropriate. He must be able to tolerate stress situations positively, without requiring motor activity to dissipate anxiety.

The chances of finding men to meet these requirements were increased by the preselection process. Eligibility for the mission was restricted to test pilots who had repeatedly demonstrated their ability to perform functions essential for the Mercury project. Records of men in this category were reviewed to find those best suited for the specific demands of the mission. A group of 69 were then invited to volunteer. The 55 who accepted were given a series of interviews and psychological tests. On the basis of these data, 32 were chosen for the final phase of the selection program. This phase was designed to evaluate each candidate's medical and psychological status, as well as to determine his capacity for tolerating stress conditions expected in space flight.

The psychological evaluation included 30 hours of psychiatric interviews, psychological tests, and observations of stress experiments. The information obtained was used to rate candidates on a 10-point scale for each of 17 categories. Ratings were made on the basis of specific features of behavior—both as indicated by the past history and as observed during the interviews. Even though the general population was used as a reference group, the scales are normative only in an arbitrary sense. The 10 levels represent subjective decisions on which characteristics are ideal, which are average and which are undesirable. Although the reliability among raters is excellent, validation studies have not yet been done.

The categories are:

(1) Drive: An estimate of the total quantity of instinctual energy.

(2) Freedom from conflict and anxiety: A clinical evaluation of the number and severity of unresolved problem areas and of the extent to which they interfere with the candidate's functioning.

(3) Effectiveness of defenses: How efficient are the ego defenses? Are they flexible and adaptive or rigid and inappropriate? Will the mission deprive the candidate of elements necessary for the integrity of his defensive system?

(4) Free energy: What is the quantity of neutral energy? Are defenses so expensive to maintain that nothing is left for creative activity? How large is the "conflict-free sphere of the ego"?

(5) Identity: How well has the candidate established a concept of himself and his relationship to the rest of the world?

(6) Object relationships: Does he have the capacity to form genuine object relationships? Can he withdraw object cathexes when necessary? To what extent is he involved in his relationships with others?

(7) Reality testing: Does the subject have a relatively undistorted view of his environment? Have his life experiences been broad enough to allow a sophisticated appraisal of the world? Does his view of the mission represent fantasy or reality?

(8) Dependency: How much must the candidate rely on others? How well does he accept dependency needs? Is separation anxiety likely to interfere with his conduct of the mission?

(9) Adaptability: How well does he adapt to changing circumstances? What is the range of conditions under which he can function? What are the adjustments he can make? Can he compromise flexibly?

(10) Freedom from impulsivity: How well can the candidate delay gratification of his needs? Has his behavior in the past been consistent and predictable?

(11) Need for activity: What is the minimum degree of motor activity required? Can he tolerate enforced passivity?

(12) Somatization: Can the candidate be expected to develop physical symptoms while under stress? How aware is he of his own body?

(13) Quantity of motivation: How strongly does he want to participate in the mission? Are there conflicts between motives—whether conscious or unconscious? Will his motivation remain at a high level?

(14) Quality of motivation: Is the subject motivated by a desire for narcissistic gratification? Does he show evidence of self-destructive wishes? Is he attempting to test adolescent fantasies of invulnerability?

(15) Frustration tolerance: What will be the result of failure to reach established goals? What behavior can be expected in the face of annoyances, delays, or disappointments?

(16) Social relationships: How well does the subject work with a group? Does he have significant authority problems? Will he contribute to the success of missions for which he is not chosen as pilot? How well do other candidates like him?

(17) Overall rating: An estimate of the subject's suitability for the mission. This is based upon interviews, test results, and other information considered relevant.

It can be seen that categories 1, 2, 4, and 10 are largely economic constructs; 3, 5, 6, and 7 are ego functions: while the rest are specific characteristics considered important for space flight. The categories represent many different levels of abstraction and are not independent dimensions. In the final analysis, they are less a means of quantifying data than of organizing their interpretation. Not only do they provide a method to compare one subject with another, but also tend to focus attention on the material most closely related to the mission requirements.

An initial evaluation of each man was made by two psychiatrists, through separate interviews during the preliminary screening period. One interview was devoted primarily to a review of the history and current life adjustment, while the other was relatively unstructured. Finally, ratings were compared, information pooled, and a combined rating made. Areas of doubt and disagreement were recorded for subsequent investigation.

The men accepted for the final screening procedure were seen again several weeks later, after an intensive evaluation of their physical status had been completed. Each candidate was reinterviewed and the following psychological tests were administered:

Measures of motivation and personality

(1) Rorschach.
(2) Thematic apperception test.
(3) Draw-a-person.
(4) Sentence completion test.
(5) Minnesota multiphasic personality inventory.

(6) Who am I?: The subject is asked to write 20 answers to the question, "Who am I?" This is interpreted projectively to give information on identity and perception of social roles.

(7) Gordon personal profile: An objective personality test yielding scores for "ascendency," "responsibility," "emotional stability," and "sociability."

(8) Edwards personal preference schedule: A forced-choice questionnaire measuring the strengths of Murray's needs.

(9) Shipley personal inventory: Choices are made from 20 pairs of self-descriptive statements concerning psychosomatic problems.

(10) Outer-inner preferences: A measure of interest in and dependence on social groups.

(11) Pensacola Z-scale: A test of the strength of "authoritarian" attitudes.

(12) Officer effectiveness inventory: A measure of personality characteristics found in successful Air Force officers.

(13) Peer ratings: Each candidate was asked to indicate which of the other members of the group who accompanied him through the program he liked best, which one he would like to accompany him on a two-man mission, and which one he would assign to the mission if he could not go himself.

Measures of intellectual functions and special aptitudes

(1) Wechsler adult intelligence scale.

(2) Miller analogies test.

(3) Raven progressive matrices: A test of nonverbal concept formation.

(4) Doppelt mathematical reasoning test: A test of mathematical aptitudes.

(5) Engineering analogies: A measure of engineering achievement and aptitudes.

(6) Mechanical comprehension: A measure of mechanical aptitudes and ability to apply mechanical principles.

(7) Air Force officer qualification test: The portions used are measures of verbal and quantitative aptitudes.

(8) Aviation qualification test (USN): A measure of academic achievement.

(9) Space memory test: A test of memory for location of objects in space.

(10) Spatial orientation: A measure of spatial visualization and orientation.

(11) Gottschaldt hidden figures: A measure of ability to locate a specified form imbedded in a mass of irrelevant details.

(12) Guilford-Zimmerman spatial visualization test: A test of ability to visualize movement in space.

In addition to the interviews and tests, important information was obtained from the reactions of each candidate to a series of stress experiments simulating conditions expected during the mission. Neither the design of these tests nor the physiological variables measured will be discussed. Phychological data were derived from direct observation of behavior, postexperimental interviews, and administration before and after each run of alternate forms of six tests of perceptual and psychomotor functions. These procedures were:

(1) Pressure suit test: After dressing in a tightly fitting garment designed to apply pressure to the body during high altitude flight, each candidate entered a chamber from which air was evacuated to simulate an altitude of 65,000 feet. This produces severe physical discomfort and confinement.

(2) Isolation: Each man was confined to a dark, soundproof room for 3 hours. While this brief period is not stressful for most people, data are obtained on the style of adaptation to isolation. This procedure aids in identifying subjects who cannot tolerate enforced inactivity, enclosure in small spaces or absence of external stimuli.

(3) Complex behavior simulator: The candidate was required to make different responses to each of 14 signals which appeared in random order at increasing rates of speed. Since the test produces a maximum of confusion and frustration, it measures ability to organize behavior and to maintain emotional equilibrium under stress.

(4) Acceleration: The candidates were placed on the human centrifuge in various positions and subjected to different G loads. This procedure leads to anxiety, disorientation, and blackout in susceptible subjects.

(5) Noise and vibration: Candidates were vibrated at varying frequencies and amplitudes and subjected to high energy sound. Efficiency is often impaired under these conditions.

(6) Heat: Each candidate spent 2 hours in a chamber maintained at 130°. Once again, this is an uncomfortable experience during which efficiency may be impaired.

After all tests were completed, an evaluation of each man was made by a conference of those who had gathered the psychological data. Final ratings

were made in each category described previously, special aptitudes were considered, and a ranking within the group was derived. By combining the psychiatric evaluations, results of the physical examinations and physiological data from the stress test procedures, the group was subdivided under the headings "Outstanding," "Recommended," and "Not Recommended." Finally, seven men were chosen from the list according to the specific needs of the Mercury project.

IMPRESSIONS OF CANDIDATES FOR SPACE FLIGHT

Although the results of the selection program can't be assessed for several years, impressions derived from psychiatric evaluations of these candidates are of interest. In answer to the question, "What kind of people volunteer to be fired into orbit?" one might expect strong intimations of psychopathology. The high incidence of emotional disorders in volunteers for laboratory experiments had much to do with the decision to consider only candidates with records of effective performance under difficult circumstances in the past. It was hoped that avoiding an open call for volunteers would reduce the number of unstable candidates.

In spite of the preselection process, we were surprised by the low incidence of such disorders in the 55 candidates who were interviewed. For the 31 candidates who survived the initial screening and physical examination, repeat interviews and psychological tests confirmed the original impressions. There was no evidence for a diagnosis of psychosis, clinically significant neurosis, or personality disorder in any member of this group.

Certain general comments can be made concerning the 31 men who received the complete series of selection procedures. The mean age was 33, with a range from 27 to 38. All but one were married. Twenty were from the Midwest, Far West, or Southwest. Only two had lived in large cities before entering college. Twenty-seven were from intact families. Twenty were only or eldest children. (In this connection, it is perhaps worth noting that four of the seven men chosen are named "junior.") Pronounced identifications with one parent were about equally divided between fathers and mothers, although mothers with whom such identifications were present were strong, not infrequently masculine figures.

Impressions from the interviews were that these were comfortable, mature, well-integrated individuals. Ratings in all categories of the system used consistently fell in the top third of the scale. Reality testing, adaptability, and drive were particularly high. Little evidence was found of unresolved conflict sufficiently serious to interfere with functioning. Suggestions of overt anxiety were rare. Defenses were effective, tending to be obsessive-compulsive, but not to an exaggerated degree. Most were direct, action-oriented individuals, who spend little time introspecting.

Although dependency needs were not overly strong, most showed the capacity to relate effectively to others. Interpersonal activities were characterized by knowledge of techniques for dealing with many kinds of people. They do not become overly involved with others, although relationships with their families are warm and stable.

Because of the possibility that extreme interest in high performance aircraft might be related to feelings of inadequacy in sexual or other areas, particular emphasis was placed on a review of each candidate's adolescence. Little information could be uncovered to justify the conclusion that unconscious problems of this kind were either more or less common than in other occupational groups.

A high proportion of these men apparently passed through adolescence in comfortable fashion. Most made excellent school and social adjustments. Many had been class presidents or showed other evidence of leadership.

Most candidates entered military life during World War II. Some demonstrated an unusual interest in flying from an early age, but most had about the same attitudes toward airplanes as other American boys. Many volunteered for flight training because it provided career advantages or appeared to be an interesting assignment.

Candidates described their feelings about flying in a variety of terms: "something out of the ordinary," "a challenge," "a chance to get above the hubbub," "a sense of freedom," "an opportunity to take responsibility." A few look upon flying as a means of proving themselves or to build confidence. Others consider it a "way for good men to show what they can do."

Although half the candidates volunteered for training as test pilots, the others were selected because of achievements in other assignments. Most view test flying as a chance to participate in the development of new aircraft. It enables them to combine their experience as pilots and engineers. Their profession is aviation and they want to be in the forefront of its progress. Danger is admitted,

but deemphasized—most feel nothing will happen to them. But this seems to be less a wishful fantasy than a conviction that accidents can be avoided by knowledge and caution. They believe that risks are minimized by thorough planning and conservatism. Very few fit the popular concept of the daredevil test pilot.

Although attempts have been made to formulate the dynamics underlying the pursuit of this unusual occupation, generalizations are difficult to make. Motives vary widely. While it is clear that conscious reasons may be unrelated to unconscious determinants, the variation in conscious attitudes illustrates the impossibility of a single explanation for a career which has different meanings for different individuals. One man, for example, stated that he enjoys flight testing because it allows him to do things which are new and different. He enjoys flying the newest aircraft available—vehicles that most pilots will not see for several years. Another is an aeronautical engineer who is primarily interested in aircraft design. He looks upon a flight test much as the researcher views a laboratory experiment.

Reasons for volunteering for Project Mercury show a mixture of professionalism and love of adventure. Candidates are uniformly eager to be part of an undertaking of vast importance. On one hand, space flight is viewed as the next logical step in the progress of aviation; on the other, it represents a challenge. One man expressed the sentiments of the group by saying, "There aren't many new frontiers. This is a chance to be in on one of them." Other expressions included: "a new dimension of flight," "a further stage in the flight envelope of the manned vehicle," "a chance to get your teeth into something big," "the sequel to the aviation age," a "contribution to human knowledge," "an opportunity for accomplishment," "the program of the future," "an interesting, exciting field," "a chance to be on the ground floor of the biggest thing man has ever done."

At the same time, most candidates were practical. They recognized that this project will benefit their careers. To some it is a chance to insure an interesting assignment. Most recognize the trend away from conventional manned aircraft and look upon the Mercury project as a means for getting into the midst of future developments. One said: "We're the last of the horse cavalry. There aren't going to be many more new fighters. This is the next big step in aviation. I want to be part of it." Most are aware of the potential personal publicity and feel this would be pleasant, but "not an important reason for volunteering."

Although all candidates are eager to make the flight, it is not their only concern. Most want to participate in development of the vehicle and have an opportunity to advance their technical training. The orbital ride is partly looked upon as a chance to test an item of hardware they have helped develop. Risks are appreciated, but accepted. Most insist they will go only when the odds favor their return. No one is going up to die. They are attracted by the constructive rather than the destructive aspects of the mission.

Psychological tests of these 31 men indicate a high level of intellectual functioning. For example, the mean full-scale scores for the seven who have been selected range from 130 to 141, with a mean of 135. The pattern is balanced, with consistently high scores on both verbal and performance subtests.

Projective measures suggest the same healthy adaptations seen in the interviews. Responses to the Rorschach, for example, were well organized. Although not overly rigid, they did not suggest much imagination and creativity. Aggressive impulses tended to be expressed in action rather than fantasy.

Behavior during the isolation and complex behavior simulator tests—which might be considered input-underload and input-overload situations—showed evidence of great adaptability. No candidate terminated isolation prematurely and none viewed it as a difficult experience. As might be expected for this brief exposure, no perceptual changes were reported. Fifteen subjects "programed" their thinking in isolation. In five of these men, the attempt to organize thoughts was considered evidence of an overly strong need for structuring. Sixteen permitted random thought, relaxed and enjoyed the experience. Most slept at least part of the time.

When placed under opposite conditions—with too much to do instead of too little—the candidates were usually able to keep from falling hopelessly behind the machine. Only a few were troubled by the impossibility of making all responses promptly. The majority became content to do as well as possible, showing a gradually increasing level of skin resistance, even though working at a frantic pace.

Reactions to physiological stressors correlated positively with the psychiatric evaluations. Candidates who had been ranked highest on psychological variables

tended to do best in acceleration, noise and vibration, heat, and pressure chamber runs. Their stress tolerance levels were among the highest of the hundreds of men subjected to these procedures in the past. Uncomplaining acceptance of the discomforts and inconviences of this phase of the program appeared to reflect not only their strong motivation, but also their general maturity and capacity to withstand frustration.

In summary, it is suggested that the most reasonable approach to selecting men for doing something no one has done before is to choose those who have been successful in demanding missions in the past. To decrease the probability of error, a broad sample of behavior must be observed. Every effort should be made to make these observations as relevant to the expected demands of the mission as possible.

By selecting only those candidates who were able to adapt to whatever conditions confronted them, we hope we have found those who are best qualified for space flight. Our confidence is further strengthened by the attitudes of the men who were chosen. Most reflected the opinion of the candidate who, when asked why he had volunteered, explained: "In the first 50 years since the Wright brothers, we learned to fly faster than sound and higher than 50,000 feet. In another 5 years we doubled that. Now, we're ready to go out 100 miles. How could anyone turn down a chance to be part of something like this?"

4. "MAN ALIVE IN OUTER SPACE"

(By Thomas R. A. Davis, M.D.)

[From the Atlantic Monthly, March 1960]

[What scientific precautions must our doctors take to insure that man can be projected into outer space and return alive? The question is no longer academic: Russian scientists have predicted that their astronauts will be ready for the adventure within 2 years. Dr. Thomas R. A. Davis is director of environmental medicine for the U.S. Army Medical Research Laboratory].

Space travel for man is imminent. Engineers have already supplied us with the vehicles. Admittedly, some of them are still unreliable and, for technical reasons, some will never become reliable. However, certain of them are now operational and have 90-percent reliability. Although the engineers of these missiles have presented man with the means of travel to outer space, the medical biologists have been slow to accept this fact and find themselves somewhat short on knowledge and understanding of how man can go into space and remain alive. Except within a fairly limited range, we cannot change man's existing modus operandi, and we can therefore take no other view than that his entry into the new environment is merely an extension of our current knowledge of human biology.

Biologically, the principal problems which will confront man in outer space are: First, the necessity of operating in a virtual vacuum; second, weightlessness, the result of operating under zero or reduced gravity; third, protection against the extremes of solar and nuclear radiation; and, fourth, adjustment to high acceleration and deceleration.

No biological system that we know of at present can operate in a vacuum, and therefore an artificial environment compatible with man's logical requirements must be contrived. For each of the five components affecting the proper functioning of man—namely, oxygen, barometric pressure, carbon dioxide, humidity, and temperature—there is a relatively narrow limit outside of which his system will not function either efficiently or comfortably. Our failure to recognize such limits has already cost animals their lives while they were still on the launching pad.

Juggling with an artificial environment is a necessity because, except for short flights, the engineers tell us that a life-support capsule operating under reduced atmospheric pressure would be lighter and easier to engineer than one in which the normal sea-level pressure of 14.7 pounds per square inch is maintained. The high-altitude studies which have been going on for a number of years do not provide a solution, because they are carried out with oxygen deprivation, neither necessary nor desirable in a space-capsule environment.

Because we have not had a need to know, we have not tried to find out the relationship between barometric pressure and oxygen percentage in terms both of toxicity from too much oxygen and of hypoxia, a condition of less oxygen in tissues than is required for their proper metabolism. Until experiments to determine this relationship on a short- and long-term basis are carried out both with animals and man, we will be working entirely in the dark. Already the preliminary work being done indicates that the relationship is more complex than we had hitherto estimated.

The safe level of carbon dioxide, which along with water is a respiratory waste product of metabolism, is much easier to control than is the safe oxygen level, and as long as carbon dioxide is kept at less than 1 percent, it can do little, if any, harm. However, if at a different atmospheric pressure its percentage increases significantly, we may have problems to solve.

THE TEMPERATURE OF SPACE

One cannot measure the temperature of space with a thermometer because, for all practical purposes, there is nothing to measure. If one puts a thermometer into space, one is measuring the temperature of the thermometer itself; this is the resultant of the radiant heat it is receiving on its sunny side and the radiant heat it is losing on its shady side. Since the heat loss to the cosmos is constant and only the heat gain from the sun varies with distance from the Sun, the nearer in space an object is to the Sun, the higher will be its final temperature, while the further away, the colder this temperature will be.

Unlike the Earth, our space vehicle will have no buffering atmosphere around it, and so we can expect a potential temperature of about 250° F. on the sunny side and about −250° F. on the shady side. It is unlikely that this will actually be the case, especially if the construction materials of the spaceship have good thermal conduction properties and if its atmosphere is assisted in its thermal convection properties by the simple act of stirring. Stirring will occur as part of the system used to remove carbon dioxide and water, the waste products of respiration.

From actual measurements in space, it seems that, in the terrestrial orbit area, we may have trouble in keeping the spaceship atmosphere cooled to the required comfortable temperature. This is especially so since each astronaut gives off an average of 500 B.t.u.'s per hour and since our electronic equipment inside the capsule will also be giving off heat. Fortunately, we can obtain temperature control by varying the ratio between the sunny and the shady side, a relatively simple operation. This system of temperature control would work within certain limits near the terrestrial orbit but should be adequate as long as our exploration is confined to the Moon and the neighboring planets. Interstellar travel will pose more difficult questions. Between the area where we lose our solar thermal radiation and that where we gain the radiation equivalent of the next star, we can expect the temperature of the space capsule to drop as low as −273° F.

The high temperatures encountered on reentry into the Earth's atmosphere are due to the friction caused by the high speed of the vehicle passing through air, when temperatures of greater than 3000°

F. can occur. The production of such an extreme of temperature is the result of the ballisticlike nature of our present missiles. If the costly payload could be increased to carry enough fuel to allow the spaceship to slow down for a soft landing, high temperature of reentry could be avoided, but because at present this is not the case, our astronauts are going to have to experience some very warm moments. If this period of high temperatures were short, there would be no great difficulty, but, unfortunately, the very insulation which prevents the heat of surface friction from affecting the capsule too severely also prevents the rapid loss of that heat which is conducted into it. It has has already been announced that the temperature of the capsule intended for a man could be kept at around 150° F. during reentry. During the Able-Baker flight, a deviation of less than 1° F. from the specified capsule temperature was achieved.

A nude man is physiologically a tropical animal, and at rest he is most comfortable at temperatures of 80° to 86° F. with a relative humidity of 50 to 60 percent. In this area, he is in what we call "thermal neutrality." That part of his circulation which is concerned with the regulation of his normal body temperature is at rest, his sweat glands are at rest, his metabolic needs are minimal, and environmentally he is completely unstressed. Above this temperature range, there are changes in his circulation, respiration, sweating, and metabolism which enable him to maintain the body temperature that nature has chosen for him. Primarily, this increase is costly in fluids, which are lost in the form of sweat. Below this temperature, man has to stoke up the internal fires, a reaction costly in food and oxygen, and to some extent in fluid also.

I would venture to say that, in the recent past, a number of animals have died because of our failure to recognize that the narrow limits of thermal neutrality greatly increase the effects of other physical stresses that are less controllable during preflight, actual flight, and recovery. The best operating temperature for our capsule is determined by the type of clothing its occupant is going to wear. Since in the Able experiment the animal was to be encased in a restraint harness with padding of unknown thermal properties, the thermoneutral range had to be determined by experiment prior to the 72-hour period of the animal's enclosure within the capsule.

The thermoneutral range of both man and animals can be extended by conditioning. Human subjects have been conditioned to the extent that they are able to sleep in the nude at 50° F. room temperature, and if you do not think this is a neat trick, try it sometime. Conditioning to heat can also be achieved, and, happily, cold and heat conditioning can coexist, greatly increasing the resistance of man to injuries of thermal extremes.

Relative humidity is a less complicated problem, so long as it is kept near the range of 50 to 60 percent for all temperatures. If humidity is too high, man cannot carry out the normal minimal fluid exchange that should take place, while if it is too low, regardless of temperature, he will suffer from excessive fluid exchange and the tendency will be toward dehydration. Therefore, both the upper and lower limits of relative humidity must be established in the capsule for proper physiological efficiency.

WEIGHTLESSNESS

There are some scientists who strongly believe that weightlessness will create a tremendous difficulty in outer space, and to support this theory some very fancy physiological assumptions have been put forward. There are scientists who think that weightlessness will cause only a partial difficulty, similar to seasickness. Still others think that weightlessness will cause no physiological or psychological difficulties whatsoever.

The state of weightlessness is brought about by the absence of gravity in space and cannot be simulated for any useful period of time within the environs of the Earth. Earth's gravitational force, 1 g, is the unit used not only to describe degrees of weightlessness but also to describe forces which increase the weight of mass above its static weight on Earth. Such forces occur during acceleration or deceleration and also when a mass is rotated on a centrifuge. G forces of greater than 1 g are easy to simulate on Earth, either by the use of a centrifuge or by a fast accelerating and decelerating vehicle. What you feel in the seat of your pants when you mash down the accelerator of your car is g force; in reverse, this is also what you feel when you apply the brakes, and both are identically expressed. G forces less than 1 g cannot be simulated on Earth except for a few seconds during high-speed parabolic flight. These few seconds of weightlessness are of no real help in the study of its physiological or psychological effects because the body cannot adjust in the time available. This inability to adjust has led some scientists to believe that there may be a constant feeling of falling and of spatial disorientation as a consequence of weightlessness.

This theory could be quite wrong. Falling is associated with acceleration, while reduced weight or complete weightlessness need not be so associated. The forces of acceleration and deceleration are a changing state which is reported as such by the organs of position and balance, and spatial disorientation is suspected, presumably, because the organs responsible for orientation are now free floating and without weight. The enigma cannot be solved unless we know whether our organs are mass-weight or mass-inertia dependent. Weight alters during weightlessness in space, but mass and its inertia are always the same, whether on Earth or in space.

During Able's flight through space, she was weightless for about 10 to 12 minutes, and there was no physiological change detected as a result of this. The inflight movies indicate that, psychologically, the monkey was quite undisturbed by finding herself in this strange state. It is probably true, that regardless of the physiological effects, the ordinary acts of living will be somewhat difficult during weightlessness, and especially will this be so on the space satellite stations, which are considered to be a necessity as way stations and takeoff points for exploration of the Moon, the planets, and of space itself. These satellite stations will orbit around the Earth and will be manned by construction crews building true space vehicles.

The engineers and physicists tell us that it is their intention to rotate these satellite stations in order to provide them with artifical gravity by the use of centrifugal force and at the same time to overcome all the problems of weightlessness. These specialists do not

appear to realize that rotation creates an interesting but disturbing set of medical problems associated with the organs of balance. If a man or an animal is rotated and the axis of his vestibular apparatus is changed, as in nodding or tilting of the head, some wonderfully fantastic and highly disturbing results take place, similar to those we experience during a ride on a super roller coaster. Very few individuals can tolerate much of this. Some vomit, some manage to emerge with only a pale-green complexion, and others have to go to bed to recover.

Current research has done much to define the psychophysiology of the problem. The adverse effects of rotation vary greatly from one individual to another, professional dancers and acrobats are the least affected. If rotation is necessary, there is some glimmer of hope, for it has been shown that animals and man have a fairly rapid ability to adapt to the effects of rotation.

The space engineers glibly set up conditions without due regard for the biological implications of those conditions. They murmur of weightlessness, but the biologists visualize only an astronaut having difficulties with his balance mechanism. For the past several years, results of experiments indicate that rotation may be a worse problem than weightlessness. Rotation is used not only to establish artificial gravity in space but also to stabilize vehicles in order to overcome the problems of tumble. This is especially important during reentry into an atmosphere, when violent vibration of the space vehicle takes place. And vibration has a nebulous gamut of biological problems all of its own. This vibration of reentry appeared to be the only event during flight that caused Able disturbance.

NUCLEAR RADIATION

Nuclear radiation in space has been demonstrated by James Van Allen and his colleagues as consisting of a doughnut-shaped belt which surrounds the earth and is primarily centered over the equatorial and temperate regions of the globe, with its inner edge about 400 to 1,000 miles distant from it and its outer edge approximately 70,000 miles out. Although the intensity of this belt is fairly well delineated, we have no idea of its effect upon biological systems. Furthermore, we do not as yet completely know what types of radiation compose this band. Animal experiments designed to tell us what harmful effects, if any, may be caused by entry into it would be desirable before we expose an astronaut to its unknown quantity. Of course, in order to cut down the exposure as much as possible, we could rush our astronaut through the Van Allen radiation belt at very high speed, provided that it is as confined as is currently believed, a supposition that seems to become more dubious as the days go by.

Below, within, and beyond the Van Allen radiation belt, we must contend with heavy cosmic particles which travel with a tremendous energy and leave destructive tracks in animal tissue, each of which is about the diameter of twenty blood corpuscles. In the area between the Earth's atmosphere and the inner edge of the belt, we know that these particles occur frequently enough to damage the tissue of animals in high balloon flights. Their strike is apparently not felt by biological specimens, and the effect of their damage is conjectural.

Radiobiologists are of the opinion that if one of these cosmic particles should strike an important area of the brain, a man could be put out of action. It must be remembered that the brain is not composed of finite pinpoint areas but of a large association of cells, the destruction of a small part of which would be unlikely to produce any undesirable effect. The only question that remains is "How many holes in the head can a man or an animal stand?" and to date we are not sure of the answer. We must make sure through adequate animal experiments, especially if we plan to have a manned satellite station rotating around the Earth within the area of cosmic radiation.

In this area, the Able-Baker flight lasted approximately 10 minutes, and two strikes of such particles occurred on the sensitive plates designed to record the heavy particle concentration. Able's death from anesthesia 5 days after the flight allowed exhaustive histopathologic examinations to be made of her tissues, and no heavy particle tracks were found. Baker, who is still alive and well, has shown no evidence that she was in any way affected by such radiation. A conclusion of "no effect" can be made only for a similar flight path and for a similar duration in space. Longer periods in this area of space are required before definite conclusions can be drawn.

ACCELERATION AND DECELERATION

Although acceleration is the process of speeding up and deceleration is the process of slowing down, the net effects of the two forces are the same, so that physiologically we can speak of them as being one.

Newton's first law states that a body either remains at rest or progresses in uniform motion. Because there is no resistance in outer space, the velocity which a body achieves is maintained without any propulsive assistance. The velocity, its direction, and the distance from Earth determine whether an object will soar on into space, will fall back to Earth, or will go into orbit.

Currently, our methods of propulsion into space consist of giving the space vehicle a high velocity after a short period of time and then allowing the vehicle to continue on its own in free flight without further help. Such a method of propulsion demands that, in order to get into true space, we reach the Earth's escape velocity of about 7 miles per second. To achieve this velocity, efficiency of the method requires high accelerative g forces.

A return to Earth obviously demands that we apply slowdown methods involving high decelerative g forces. In our present ballistic approach to space travel, deceleration has to be achieved in a relatively short distance, and therefore in a relatively short time, so that, usually, much higher g forces are attained in landing than in takeoff. In the Able-Baker flight, g forces during reentry were three and a half times greater than those during takeoff. Although g forces during takeoff and recovery can be mitigated by engineering design, which will require larger funds than have so far been made available, the escape velocity of 7 miles per second is necessary only because of the current ballistic approach. If we had a long enough ladder and could spare the time, we could climb up into space and back with no g forces of consequences to worry us. This would also be true if we had a space vehicle which could main-

tain a constant speed when it was pointed toward space. In both instances, we would eventually arrive in outer space; so perhaps future spacemen will look back at our present propulsion methods and smile at the crudity of their forefathers, who contemplated putting a man into a rocket and then firing him off into the blue.

Our chief medical concern with accelerative and decelerative g forces is their effect upon man's circulatory system. We need to find out whether there will be impairment of its function of supplying oxygen and nutrition to tissues and carrying away the waste products of tissue metabolism, which the respiratory system eliminates as water and carbon dioxide and the urinary system eliminates as a multitude of end products. The difficulty arises from the fact that, for all practical purposes, the vascular system obeys the laws of hydrostatics.

Fluids are not easily compressed, a fact put into use in the many hydraulic systems, including the braking system of an automobile. And fluids seek their own level. At 1 g, or the force of gravity on Earth, when we are standing up the blood tries to flow out of our toes and is prevented from doing so only by the competence of our blood vessels. Blood cannot go to our brains without the pumping action of our hearts. The heart is sensitive to changes in hydrostatic pressure, to the degree that the mere raising of an arm can be reflected in its compensatory reaction. When we lie down the hydrostatic pressures more or less equalize, and blood goes to the head or to the feet with equal facility.

Under all normal circumstances on Earth, the efficiency of the vascular system far outweighs these hydrostatic effects. At 0 g, which is weightlessness, these effects do not exist, and any position is as good as the next one. However, at g forces greater than 1 g, these potencies can be expected to increase in direct relation to the amount of g force applied, so that now position becomes extremely important. Insofar as the direction of the applied g force is concerned, the position which allows no point of the vascular system to be higher than another would give the best results. Under sufficient g force the position which allows the head to lead in the direction of acceleration would drain the brain of blood and cause a blackout through oxygen starvation. Theoretically, the position where the long axis of the body is perpendicular to the force would be the best choice.

In the Able-Baker flight, g forces encountered caused Able to increase her heart rate, while little Baker's rate decreased. I have reported this as being perhaps due to the fact that Able did not have the most important part of her anatomy perpendicular to the g force, while Baker did. If this contention is true, then the dynamics of circulation in the critical anatomical areas require further study, so that our spaceman will not be subjected to unnecessary stress or trauma.

VISION IN SPACE

As an example of some of the lesser difficulties in space medicine, consider the question of vision. Without the buffer of the natural terrestrial atmosphere, the radiation of visual light and infrared and ultraviolet rays will be maximal, so that filters and other specialized protective equipment will be necessary for an astronaut. Also,

owing to the absence of an atmosphere, tremendous contrasts between lighted objects and the darkness of space may pose some visual problems.

Perhaps the most serious visual difficulty for an astronaut may be the condition of empty-space myopia. At rest, our eyes tend to accommodate for a distance of about 6 feet, so that objects beyond this distance are out of focus and not readily perceived. On the ground and in ordinary flying, this circumstance causes no severe problem, since our eyes can quite rapidly accommodate to distant scenery by progressive accommodations to a series of objects. However, traveling in space, a man does not have this procession of objects in front of him, and with his eyes at the resting accommodation of 6 feet or less, he has no yardstick by which he may determine whether his eyes are focusing at 6 feet or at infinity. As a result, objects even as close as a hundred feet can be completely missed visually. For exactly these reasons, the difficulties of vision are a plague to our high-flying jet pilots.

THE NEED FOR BASIC RESEARCH

All of the foregoing might lead one to conclude that space is an outrageously dangerous area to be entered by man. Some have chosen to make an issue out of the difficulties, while others have overminimimized them. Doubtless the truth lies somewhere in between. In order to be sure of the extent of likely dangers, biological investigation using animals should have high priority on any program concerning outer space. From what I can glean of the efforts of space scientists in Soviet Russia, the necessity is fully recognized, and Russian biological research is probably ahead of ours. To place a man in space without biological research would be equivalent to developing a polio vaccine by using human subjects instead of animals. The successful efforts carried out in the United States which are worthy of the term bioflight are few.

During the Able-Baker flight, Able had to live restrained inside the capsule and in the artificial environment created for her there for a total period of almost 72 hours—such a lenghty time being required because the biological experiment could not interfere with the primary engineering mission of this particular missile. Even so, the engineers were able to build into the capsule all of the environmental criteria that were requested of them, and they built it to such a degree of exactness that the animals were able to reenter the world alive and well.

Although some neurological and psychological experiments have been performed using simians, physiological baseline data are relatively lacking for the monkey family. These baseline data take years to collect and evaluate and are already available for other animals, such as the rat and the dog. The claim that the physiology of a chimpanzee or a rhesus is most like that of man is not based upon sufficient research evidence. Physiologists have generally avoided using members of the monkey family as experimental subjects, because of their much greater cost and because they are not the easiest animals to handle. To use them as primary test animals to determine the physiological effects of space is likely to land us in the position of having data which may be difficult to interpret.

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In the animal bioflights so far carried out, our knowledge of the biological effects of space is given a good start. But it is only a start. A flight of such a few animals into space for such short periods cannot provide many answers. The variations of the response of biological systems to drugs, environments, or social stresses differ greatly between individuals. If we put 10 animals or 10 men into a cold room, 2 might become frost bitten, 3 might become hypothermic without frostbite, and the other 5 might be quite happy, although all were in the same situation. We cannot rely upon the meager results so far obtained.

Space medicos understand that grim determination is necessary to carry out a bioflight successfully. They know, too, that their specimens can get back alive, and they will work minutely to see that they do get back alive, never daring to delegate without checking and doublechecking. When I hear on a news broadcast that a handful of valueless little white mice have died in an effort to reach outer space, to me there is nothing casual in the implication. There is no exultation when a missile has to be destroyed. To space scientists these things are steps backward in the national effort, for which all of us, no matter to what service we owe our particular allegiance, wish only success and progress.

The topsy-turvy growth of the missile program has affected the medical and biological aspects of space research no less than it has its other aspects. The dream of every space scientist is space travel for man, but up to now the picture of the biological programs necessary to be carried out has not been clear. Injury to our first man in space can put our program back for years, and there would seem to be a need for further animal experimentation before we proceed. There are still many who believe that simulated conditions of space within a laboratory will tell us all, presupposing that we know all the conditions to be encountered during a space flight. Even if they were right, we would have to check our suppositions by the use of animal flights. Furthermore, Van Allen's belt of radiation, cosmic radiation, and weightlessness cannot be simulated or assessed here on earth.

Space flights using animals cannot be regarded as anything more than a checking process, while in the laboratory we do the basic work, such as the study of the relationship between oxygen and barometric pressure and its effect upon respiration physiology; the study of the effects of radiation upon biological tissue and the protective measures against its ill effects; the study of rotation upon the vestibular system; the study of the dynamics of the vascular system during high g forces.

Space scientists are constantly faced with the question "Why does man wish to explore space?" A mountain climber once told a newspaper reporter that he risked his neck climbing to the tops of mountains simply because the mountains were there, a reply which, despite its complete lack of reasoning, seems to have great public appeal and may be sufficient answer to the present question. Explorations in the past have yielded benefits far beyond what could possibly have been predicted, and it would be unusual if explorations of space did not yield parallel benefits.

It is reported that it took Columbus 7 years to induce Queen Isabella to sell her jewels to finance the expedition which has resulted in all

that Americans now hold dear. Isabella got very little in return for her investment at the time. The Phoenicians and the Dutch explored for trade; the Egyptians, the Spaniards, the Portuguese, and the British, for King Solomon's gold; only the Polynesians and the Vikings explored for the sheer joy of practicing the arts of navigation and voyaging.

Today we have other globes to explore, but let us not delude ourselves. Would we rather see our taxes go to efforts to solve the problems of space today, or would we prefer to wait and see them go to a foreign power in payment for the exports from that country's newest territory, the Moon?

5. "MAN IN SPACE . . . WHERE WE STAND"

(By Col. Paul A. Campbell, Chief, Space Medicine Division, School of Aviation Medicine, U.S. Air Force [1])

Those of us associated with research toward the goal of manned spaceflight feel that its eventual accomplishment is inevitable and that its accomplishment is a logical, rational development in the evolution of man and the evolution of the metagalactic universe.

Man has certain attributes, physiological, psychological, and sociological, which have resulted in rational, step-by-step progress toward space. A few of these are:

His natural curiosity which constantly asks him what lies beyond the clouds, the blue sky, and the stars.

His spirit of adventure from which he may gain enjoyment from going places and doing things outside the ordinary. In many cases he enjoys sufficient danger to separate him from the "meek who shall inherit the earth."

His refusal to be contained by barriers which restrict him or his activities.

His quest for achievement of which he, his family, etc., can be proud, which again sets him apart from his fellow men and improves his ego.

His built-in desire to do that which he has been told is impossible.

How far man will go into space probably (and here we have all learned to couch our dogmatism with "probably") will be found to be limited to some extent at least by—

The speed of light.

The distance which he can travel and return in his productive life span. Unless he changes considerably, he will always wish to return to tell or write about his feats.

The limits of resupply within reasonable time.

The amount of radiation which he can be exposed to and remain in good health.

The statistical chances of survival, etc.

This is all well and good and gives us a framework for the future and feeds fuel to the science-fiction writers, but the cold gray dawn of each morning tells us that there is much to be done before spaceflight in its broader sense can be accomplished. We are progressing in a step-by-step fashion, but at times two steps forward and one step backward. Our forward steps sometimes bring us face to face with a new barrier, such as the Van Allen-type radiation bands, but new knowledge tempers the old and progress continues. In [our] time * * * we have seen the oxygen barrier, the bends barrier, the vapor-pressure barrier, the sound barrier, the thermal barrier, the ozone barrier, and many others appear for a time to block the extension of aviation, but each has vanished as some new breakthrough has shown the means of traverse.

Progress in each parameter has been exponential. The pauses produced by barriers have resulted in such short-lived plateaus that when viewed in the curve of progress of the 20th century—59 years to date—they seem almost

[1] Air Force and Space Digest, July 1959, pp. 65-67.

imperceivable. Aviation through rocketry, its Newtonian principle of propulsion, its lift produced by propellant rather than wings, and its ability to carry its oxidizer rather than to depend upon the atmosphere for its breath, now gives us the means for penetrating the atmospheric barrier. Where machine can go, man wishes to go and will discover, invent, or improvise the means.

But again to get back to our earth-bound laboratories and our mundane existence, let us have a look at where we stand today and point out a few of the more serious problems which slow progress toward spaceflight and require integrated, concentrated effort. Let us do a little curve watching before we look into the crystal ball.

Man and machine have been in a more or less continuous race to outdo one another since the advent of aviation. At times man, through advancements of the state of the art of protective devices and measures, has been in the lead and could go where the machine could not take him. At times the machine has been in the lead and has been able to go places and do things in which man could not participate.

Until 2 or 3 years ago the race between the aviation designers and engineers on the one hand and the flight surgeons, aviation biologists, and human factors groups on the other hand has been nip and tuck. But in these past 2 or 3 years the situation has suddenly changed, and the machine capability has advanced far beyond man's capability. Let us look at two parameters to see where we stand.

Manned altitude, or, as we must now say, distance outward, achievement has been one parameter which has been carefully watched since the Wright brothers' first flight. * * * The curve is exponential and looks good when viewed on the proper chronological base line. It ended with Kincheloe's flight [in the Bell X–2] to an altitude of 126,200 feet. But when placed within the framework of hardware achievement, it does not look so good. The man/machine gap is tremendous and is lengthening by the month.

Let us now look at another parameter—that of speed—because as we all know man cannot orbit until he reaches a speed of some 18,000 miles per hour and cannot escape the earth's gravitational tentacles until his velocity has reached some 25,000 miles per hour. First, let us examine man's speed achievements plotted chronologically. It ends with Mel Apt's fatal flight [also in the X–2] reaching about 2,148 miles per hour. Again we have an exponential curve and man appears to be doing just fine. But again, when viewed within the framework of hardware achievement, it does not look very good, and again we see a tremendous man/machine gap.

Now why has this gap lengthened so much in the past few years. I think we can point to one situation—a comparison of resources—scientists and facilities—a comparison between the hardware development area and the human factors development area. Whereas there are several thousand scientists and facilities in hardware research, design, and production, there are still only a few in space medicine, space biology, human factors, and related disciplines, and this is taking its toll in terms of integrated progress toward manned spaceflight.

The space concept is a relatively new one and is interdisciplinary throughout. Consequently, training for those who wish to participate simply does not exist except in the in-house, or on-the-job categories. Programs for training require the wedding of diverse disciplines such as astronomy and biology, astrophysics and ecology, logistics and ecology. As an example, may I point to the organizational chart of our own Space Medicine Division at the School of Aviation Medicine, USAF, to illustrate:

SPACE MEDICINE DIVISION

1. Bioastronautics:
   - Utilization of the energies of space.
   - Protection against energies of space.
   - Extraterrestrial and cosmic radiation.
   - Liaison.
2. Astroecology:
   - Ecological systems.
   - Components.
   - Ecologistics.
   - Synecology.
   - Psychological reactions.
   - Selection.
   - Training.
   - Indoctrination.

3. Biogravics:
   - Biodynamics.
   - Zero and sub "G."
   - Acceleration.
   - Deceleration.
   - Tangential acceleration.
   - Reaction control.
4. Bioastrophysics:
   - Instrumentation.
   - Design.
   - Maintenance.
   - Weight and capacity reduction.
   - Reentry.

The wedding of the disciplines here is self-evident.

May I now emphasize that the primary biological problem of manned spaceflight at this time lies in the production of people trained in the required interdisciplinary techniques and with imagination, who in turn can help produce solutions to the many complex problems which plague us.

Let us now have a look at some of the other problems in the production of a reliable manned space system and see where we stand today:

The problem of reentry is very serious as it involves relatively rapid slowdown from speeds (in the neighborhood of 18,000 miles per hour if orbiting or some 25,000 miles per hour if in escape ellipse) to zero miles per hour. If we take the example of the orbiting vehicle, the magnitude of the total energies is some 19 million foot-pounds per pound of orbiting mass. Thus, approximately 24,000 B.t.u.'s per pound of orbiting mass must be dissipated in a relatively short period of time. For comparison, the energy contained in a gallon of gasoline is about 21,000 B.t.u.'s per pound. During the same period high G loads approaching man's tolerance limits will have to be sustained. Project Mercury, the first orbiting manned spacecraft, will have to meet these requirements. Its engineers say it can be done.

Radiation.—Orbiting beneath the Van Allen bands, yet remaining above the levels of appreciable atmospheric drag, is possible. This requires an almost circular orbit between the altitudes of something like 140 miles and 400 miles. For travel into the deeper reaches of space, polar launching, to avoid the Van Allen bands, would require an exit passage almost identical with the path or entrance corridor of the maximum concentration of incoming heavy primaries. Again in the type of space travel of the relatively near future, orbiting within these bounds for short periods seems feasible.

Weightlessness.—This is another huge question mark as our simulation capability through the use of parabolic flight patterns still remains under something of the order of 60 seconds. We cannot even guess as to the effects of several hours or several days of zero G. Several of us are of the opinion, however, that an even greater problem is for the engineers to provide an absolutely stable platform which will not produce some tangential G due to rotation or tumbling. Weightlessness is possibly the lesser of the two evils.

Closed ecological systems.—For space travel of short duration such as a few circuits of the earth closed-loop ecological systems are unnecessary, but for long flights involving months such a system is an absolute requirement as resupply will be very difficult and the logistics will be exorbitant.

Human logistics of spaceflight other than resupply require capacity reduction through miniaturization, the conservation of everything, recycling, and reutilization wherever possible. There is much to be done here and it must be done as the weight costs, in terms of fuel and structure required for getting each pound of man, oxygen, food, containers, fluid, protective gear, etc. (into space), are very high.

Escape from a space vehicle in the event of accident, recovery, and survival present huge problem areas. The problems have been analyzed. The answer probably lies in constant improvement of the reliability of the primary vehicle.

(Colonel Campbell is a pioneer in the aeromedical field, having twice served as Director of Research at the School of Aviation Medicine and more recently as special assistant to the commander of the Air Force Office of Scientific Research. This article is condensed from a presentation to the Federation of American Societies for Experimental Biology in April 1959. It reflects the author's personal views and is not to be construed as a statement of official U.S. Air Force policy.)

6. EXCERPT FROM: "EXOBIOLOGY—EXPERIMENTAL APPROACHES TO LIFE BEYOND THE EARTH"

Paper read by Dr. Joshua Lederberg, January 13, 1960 (Department of Genetics, Stanford University, Medical Center Palo Alto, Calif.; Member, Committee 11 on Psychological and Biological Research, Space Science Board) at the First International Space Science Symposium [1] Nice, France, sponsored by COSPAR, Committee for Space Research, of the International Council of Scientific Unions

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PLANETARY TARGETS

The suitability for life of the accessible bodies of the solar system has already received ample attention. Mars is, of course, the likeliest target, most nearly resembling the habitat of the Earth. The indicated scarcity of free moisture and oxygen would severely limit the occupation of Mars by man or most terrestrial animals. However, there seems little doubt that many simpler, earthly organisms could thrive there. Indeed, many students have concluded that Mars does have a biota of its own. The most pertinent evidence is perhaps the infrared reflection spectrum recorded by Sinton which indicates an accumulation of hydrocarbonaceous materials in the dark areas. This is complemented by Dollfus' report (cf. this symposium) on the seasonal changes of granularity of these areas. The main reservation that must be registered is that these might be meteorological phenomena involving masses of material which may be carbonaceous but not necessarily living. Most such material on the Earth's surface is associated with life. However, this may be connected with the greedy utilization of such compounds by organisms rather than their production by vital synthesis. However, the most plausible explanation of the astronomical data is that Mars is a living planet.[2]

The habitability of Venus connected with its temperature, a highly controversial subject. Perhaps the most useful first contribution to the exobiology of this planet would be a definitive measurement of its temperature profile. Even should the surface be unbearably hot, this need not preclude a more temperate zone at another layer.

The exposure of the Moon's surface to solar radiation and its absence of a significant atmosphere have discounted the possibility of a lunar biology. However, the composition of the Moon's deeper layers, from even a few meters beneath the surface, is very much an open question (cf. Urey, this symposium) particularly in the light of Kozyrev's recent reports of gaseous emissions. Realistic plans for

[1] Preprinted from the proceedings to be published 1960 by the North Holland Publishing Co., Post Office Box 103, Amsterdam.

[2] The term "vegetation" is often used—this should be discouraged if it implies that the Martian biota will necessarily fall into the taxonomic divisions that we know on Earth.

the biological study of the Moon probably must await the results of chemical analyses. Apart from the remote possibility of indigenous life the Moon is a gravitational trap for meteoroidal material. We may eventually be able to screen large quantities of this virgin material for what Haldane called astroplankton—the empirical test of the panspermia hypothesis. While exposed deposits would be subject to solar degradation, shaded refuges must also exist. Mercury may be analogous to the Moon, except insofar as its dark side may furnish an even more reliable, though much remoter, refuge of this kind.

It may be academic to discuss the exploration of the major planets in view of their distance and the difficulty of deceleration in the Jovian field. However, their wealth of light elements, subject to solar irradiation at temperatures and in gravitational fields very different from the Earth's offers the most exciting prospects for novel biochemical systems.

EXPERIMENTAL APPROACHES

Our treatment of this topic warrants the utmost humility from a realistic view of our limitations. Useful landings on planetary targets are fraught with difficulties and hazards; opportunities for remote experiments cannot be overlooked in the excitement of planning for more adventurous missions. Stabilized extra-atmospheric platforms for large telescopes may furnish tools for planetary chemistry comparable in yield to fleeting probes to the vicinity of the targets.

It is instructive to ask ourselves how we might diagnose the existence of life on the Earth from distant observations. If we may judge from the photographs so far obtained from high altitude rockets, we could hope to detect only large-scale manifestations of organized culture—cities, roads, rockets. This reserve may not give due credit to the possibilities of high resolution photography and sensitive infrared spectrometry, and reasonable implications from seasonal changes in the color and texture of terrain. However, we may conclude that distant approaches will be invaluable for preparatory chemical information, but probably will not be decisive for exobiological inferences. Even if we could more surely decide that the Martian cycle involved living organisms rather than inanimate chemical transformations we would still have little insight into the intimate biochemical details which are a major objective of exobiological research. On the other hand, like our own extensive deserts and deep waters, a planet could harbor an extensive biota that would defy detection from a distance.

Micro-organisms, for many reasons, are the best prospects on which to concentrate marginal capabilities. They are more likely to flourish in a minimal environment than larger organisms. The microbes must also precede the macrobes in evolutionary sequence though we must not suppose that present-day bacteria are necessarily very primitive. The Earth is well endowed with both kinds of organisms; we can imagine another world with only microbes; but we cannot conceive of one lacking microbes if it bears any form of life at all. Likewise, taking the Earth as a whole, we find that large organisms occupy only a small fraction of the surface. However, we can reasonably expect to find evidence of microscopic life in any drop of water, pinch of soil, or gust of wind. Given a limited sample for

study, microbiological analysis will certainly give the most reliable diagnosis for the presence of life anywhere on the planet. By the same odds the greatest diversity of biochemical mechanisms will be represented among the microbiota of a small sample.

Microbiological probes also offer distinct advantages for the collection and analysis of living material. Starting from a single particle, microbes can easily be cultivated within the confines of an experimental device. In this they remain accessible to physiological and chemical experiments that would be extremely cumbersome for larger organisms. (Compare, for example, the automatic instrumentation that would be needed to catch a mouse or an elephant and then to determine its nutritional requirements.) The techniques of cytochemistry as have already been developed for the chemical analysis of microscopic cells and organisms appear to be the most readily adaptable to automation and telemetric recording, an important advantage under the existing pressure of time, talent and cost. Important issues of policy cannot be decisively settled without factual information on the growth capacity of the micro-organisms that might be exchanged among the planets. Accordingly, the methodological precedents in terrestrial science for exobiology are most evident in microbial biochemistry. The conceptual aims are equally close to those of biochemical genetics. Needless to say no other resource or objective of serious biological science can be neglected in the development of an experimental program.

Aside from the experimental designs, the pace of exobiological research may be regulated by advances in vehicular and guidance capabilities and data communication. In the expectation that these will remain in reasonable balance—for static or real time television communication with the planetary probe—the microscope may be the most efficient sensory instrument. The redundancy of a pictorial image is not altogether wasted: would we confide in a one-bit pulse from an efficient black box to answer our cosmic queries?

According to this experimental concept, the terminal microscope-vidicon chain must be supported by three types of development: (1) for collection and transport of specimen to the aperture of the microscope; (2) for cytochemical processing of the samples; (3) for protection of the device from environmental hazards, its apt location after landing, provision for illumination, focusing, and perhaps preliminary image selection. Detailed studies of these problems are only just underway, and the following suggestions are only tentative.

The easiest specimens to obtain may be atmospheric dust and samples of surface soil once the device has been landed. These are collected on a traveling ribbon of transparent tape which is thrown out and then rewound into the device. Larger samples, collected by a soil auger, could be subjected to a preliminary concentration of non-mineral components by flotation in a dense liquid. The use of such a tape simplifies the problem of treating the samples with a succession of reagents, for example specific enzymes and fluorescent stains which allow for the detection of nucleic acids and proteins. Microscopy with ultraviolet light, particularly at 2600 and 2800 Å [3] owing to its

[3] Editor's footnote: An Angstrom unit, also abbreviated as A.U., is used in expressing the length of light waves; it represents a minute unit of length equal to one ten-thousandth of a micron, or one hundred-millionth of a centimeter.

selectivity for nucleic acids and proteins may be the most direct way to distinguish micro-organisms from mineral particles. Generally speaking, the microscope can be adapted to many simple analytical procedures whose construction on a larger scale would present formidable problems for automatic technique.

The adaptation of the microscope system to a payload can be undertaken more realistically when laboratory prototypes have been built and tested. For example, we will have to decide between accurate prefocusing of a microscope whose lenses and entry slit are mounted in a rigid structure and continuous control of focus by an optically controlled servosystem (an innovation that would be far from useless in the biological laboratory). Fluorescent staining may facilitate automatic discrimination for conservation of radio power: the traveling ribbon can be stopped and the vidicon-transmitter activated just when a stained object is in view.

These preliminary experiments can indicate some of the general features of the planetary microbiota. The data they furnish will support more intensive studies of the growth characteristics, chemical composition and enzymatic capabilities of organisms cultivated on a larger scale. The interaction of these organisms with tissue cultures of animal cells can also be considered. From the results of these initial probes we can better deduce how to anticipate the long range consequences of the intercourse of planetary biota.

CONSERVATION OF NATURAL RESOURCES

A corollary of interplanetary communication is the artificial dissemination of terrestrial life to new habitats. History shows how the exploitation of newly found resources has enriched the human experience; equally often we have seen great waste and needless misery follow from the thoughtless spread of disease and other ecological disturbances. The human species has a vital stake in the orderly, careful, and well-reasoned extension of the cosmic frontier; it will be a crucial measure of the maturity of our national consciences and their concern for posterity, how we react to the adventuresome and perplexing challenges of space flight.

The introduction of microbial life to a previously barren planet, or to one occupied by a less adapted form can result in the explosive growth of the implant with consequences of geochemical scope. With a generation time of 30 minutes, and easy dissemination by winds and currents, common bacteria could occupy a nutrient medium the size of the Earth in a few days or weeks, being limited only by the exhaustion of available nutrients. It follows that we must rigorously exclude terrestrial contaminants from our spacecraft. This stricture must hold until we have acquired the factual information from which we can assuredly assess the detriments of free traffic, and whether these are small enough to warrant the relaxation of these controls.

At the present time, the most obvious values that would be threatened by contamination are scientific ones. The overgrowth of terrestrial bacteria on Mars would destroy an inestimable prize for the understanding of our own living nature. Even if an intemperate mission has not contaminated a planet, the threat of its having done so will confuse later studies, if Earth-like organisms are then found. How-

ever, other values are in question. Quite apart from strictly scientific concerns, would we not deplore a heedless intrusion on other life systems? It would be rash to predict too narrowly the ways in which undisturbed planetary surfaces, their indigenous organisms, their molecular resources may ultimately serve human needs. If we have cause to prejudice these values, we surely would not wish to do so by inadvertence.

To do this effectively requires a nice appreciation for the ubiquity and durability of bacterial spores, which are well preserved in high vacuums and at low temperatures, and are only rapidly destroyed when kept at temperatures over 160° C. It is probable that spacecraft can be disinfected by the conscientious application of gaseous disinfectants, especially ethylene oxide, but this will succeed only if the procedure is carried out meticulously and with controlled tests of its effectivness. Sealed components, if found to be potential sources of contamination, can be disinfected by chemicals, prior to sealing, or subsequently by heat, or irradiation at very high doses. The technology of disinfection is an expert one, and personnel already experienced in it should be delegated supervisory control.

The assessment of this problem involves a concept of risk that has not always been perceptively realized. The hazards of spaceflight itself, or of hard impact, or the planetary environment might suffice to neutralize any contaminants: but can we afford to rely on any uncertain suppositions when the stakes are so high, and when we have practical means at hand for conservative protection? We must be especially sensitive to the extreme variations in the environments of spacecraft or of planetary surfaces which might furnish refuges for microbial survival no matter how hostile the average conditions.

The indications by agencies both in the United States and the U.S.S.R. that adequate precautions will be exercised on all relevant missions are an important step in the realization of constructive exobiology.

Scientists everywhere will call for the application of these measures with the same care and enthusiasm as the more positive, exciting and patently rewarding aspects of space research. Scientific microbiology in the laboratory is absolutely dependent on the rigorous application of the special technique of pure culture with aseptic control. If we do not exercise the same rigor in space science we might as well save ourselves the trouble of thinking about and planning for exobiological research.

While early traffic to the planets will be one way, we must anticipate the capability of round trip and even of manned space flight. Undoubtedly, planetary samples can be analyzed for any scientific purpose more conveniently and more exactly in the terrestrial laboratory than by remote devices. For each step of analysis, special devices can be used (or if need be newly designed and constructed) and a constant give and take between human judgment and instrumental datum is possible. However, the return of such samples to the Earth exposes us to a hazard of contamination by foreign organisms. Since we are not yet quite certain of the real existence of planetary (i.e. Martian) organisms, and know nothing of their properties, it is extremely difficult to assess the risk of the event. The most dramatic hazard would be the introduction of a new disease, imperiling human

health. What we know of the biology of infection makes this an extremely doubtful possibility—most disease-producing organisms must evolve very elaborate adaptations to enable them to resist the active defenses of the human body, to attack our cells, and to pass from one person to another. That a micro-organism should have evolved such a capacity in the absence of experience with human hosts or similar organisms seems quite unlikely. However, a converse argument can also be put, that we have evolved our specific defenses against terrestrial bacteria, and we might be less capable of coping with organisms that lacked the proteins and carbohydrates by which they could be recognized as foreign. Furthermore, a few diseases are already known (e.g., psittacosis, botulism, aspergillosis) whose involvement of man seems to be a biological accident. These arguments can only be resolved by more explicit data. Nonetheless, if they are harmful at all, exobiota are more likely to be weeds than parasites, to act on our agriculture and the general comfort of our environment, and to be pervasive nuisances than acute aggressors. However, even the remotest risk of pandemic disease, and the greater likelihood of serious economic nuisance, must dictate a stringent embargo on the premature return of planetary samples, or craft that might inadvertently carry them. Again, our preliminary experiments must give us the foundation of knowledge to cope with exo-organisms, even select those which may be of economic benefit. A parallel development of technique for disinfection may mitigate some of these problems—at present the prospects for treating a returning vehicle to neutralize any possible hazard are at best marginal by comparison with the immensity of the risks.

Of the possible payloads for interplanetary travel, living man, of course, excites the widest popular interest. In due course, he may be supported by a sufficient payload to accomplish useful tasks in exploration beyond the capacities of instrumentation. However, he is a teeming reservoir of microbial contamination, the most difficult to neutralize, and an especially apt vehicle for infectious organisms. In view of these difficulties, and insofar as manned space flight is predicated on the return of the crew, a sound basis of scientific knowledge from instrumented experiments is a sine qua non for the planning of such missions.

Timely effort now to devise and build instrumented experiments is essential to keep pace with the technical capacities of space vehicles.

CONCLUDING REMARKS AND ACKNOWLEDGMENT

Many of the ideas presented in this statement are not new. In the scientific literature, they have been treated only occasionally, for example in a remarkable article by J. B. S. Haldane (1954). They are also anticipated in the classic works of science fiction, e.g., H.G. Wells' "War of the Worlds," and by a flood of derivative fantasies of less certain quality either as science or as fiction. This kind of attention has not necessarily helped the realistic evaluation of the biological aspects of space travel which may still be dismissed as overimaginative by some of our colleagues. However, exobiology is no more fantastic than is the realization of space travel itself and we have a grave

responsibility to explore its implications for science and for human welfare with our best scientific insights and knowledge.

The principles embodied in this paper reflect the judgment of one among several of the scientific groups advisory to the Space Science Board of the U.S. National Academy of Sciences. However, they do not necessarily represent any official policy of the committed views of each consultant. The continued interest and advice of M. Calvin, R. Davies, N. Horowitz, S. E. Luria, A. G. Marr, D. Mazia, A. Novick, C. Sagan, G. Stent, H. C. Urey, C. B. van Niel, and H. Weaver, among many others, have been indispensable.

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